

# White Paper

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**NEH – Sustaining Cultural Heritage Collections  
Collections Sustainable Storage Initiative (CSSI)**

Collections Storage Space, Environment & Equipment  
Assessment & Recommendations

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# Worcester Art Museum

30 December 2015



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## Executive Summary

**Assessment Need** With plans for a capital campaign under development and a continuing wish to improve collections storage conditions within the museum, the Worcester Art Museum applied for a NEH – Sustaining Cultural Heritage Collections planning grant to develop a Collections Sustainable Storage Initiative (CSSI) and to update the Collections Storage Improvement Study prepared by Solomon+Bauer+Giambastiani Architects Inc (SBGH) in 2004. In preparation for the grant application, Worcester Art Museum Chief Conservator Rita Albertson, and Registrar Joe Leduc attended a Sustainable Preservation Practices workshop presented by the Image Permanence Institute (IPI) in Chicago Illinois in November of 2012. They were joined at the workshop by SBGA staff members Larry Bauer, Stewart Marshall, and Karin Aslaksen. Approaches to the sustainable preservation discussed at the workshop became the basis of the Museum's successful grant application resulting in a grant award in 2013. Particular emphasis was given to updating 2004 recommendations for improvements to HVAC, fire detection, fire suppression, and lighting systems to assure the provision of highly sustainable, energy efficient, code conforming environments in collections storage areas.

A multidisciplinary consultant team led by Larry Bauer of SBGH included an HVAC Engineer specializing in museum environments, an electrical engineer, a fire protection consultant specializing in cultural heritage facilities, a building envelope consultant, and a local contractor with a long history working with the museum as a cost consultant.

**Assessment Process** The first phase of the project involved the collection of a year's worth of environmental data from all collections storage areas of the Museum. Data was collected, stored and analyzed utilizing PEM2 dataloggers and software purchased from the Image Permanence Institute (IPI) with a portion of the grant money. Jeremy Linden, Senior Preservation Environment Specialist at IPI provided assistance at the beginning of the Project in a two day consultation with the Museum and consultant project team to discuss the goals of the study, instruct Museum staff members on the use of the equipment and data analysis software, and coordinated placement and installation of the dataloggers.

**Data Analysis** Collected data generally indicated that storage areas have a relatively stable environment but with excursions of temperature and relative humidity outside the Museum's desired standards. The stability in the Museum's largest storage areas is promoted by their location in the basement of the 1932 Building enclosed by massive concrete construction damping rapid changes in environment. The lack of a fresh air supply to these spaces, although non-code compliant, also assures slow changes in environment. Collections storage areas in the Hiatt Wing also exhibited a stable environment, maintained by an air-handler with the ability to overcome deficiencies in the Hiatt Wing's exterior wall construction. Maintenance of a stable collections preservation environment within this wing is likely to have long term consequences for the building's exterior wall construction due to condensation issues within the wall construction.

**Study Recommendations** As a result of analysis of the data and known deficiencies in code conformance of the HVAC systems in the museum basement, antiquated and environmentally unfriendly fire protection systems in all the collections storage areas, and the inability of most collections storage furniture to accommodate the existing collections and future expansion of collections; an improvement program was developed with the following key features:

#### Building Envelope & General Construction

- Install new insulation, vapor retarder, and GWB wall finish at exterior walls of basement collections storage rooms North Storage and East Storage.
- Install new vapor retarder and air barrier on the interior of the exterior wall surfaces at Hiatt Second Floor Crate Storage.
- Seal and air test all penetrations in walls ceilings and floors of collections storage rooms.

#### HVAC Systems

- Replace local HVAC air-handlers and attendant humidifiers in basement storage areas North Storage, Object Storage, and Textile Storage with new units installed in Corridor MB13 fed with code minimum quantities of fresh air provided by a new fresh air AHU located in basement Mechanical Room MB22. Provide air supply distribution ductwork in each storage room to evenly move air throughout the room, especially at exterior walls.
- Replace the in-room fan coil unit and humidifier serving East Storage with a new AHU located in Mechanical Room MB22 ducted to the room through Electrical Room MB09.
- Extend fresh air supply ductwork to basement Corridor MB15 for possible future conversion of the Photo Studio, Registrar's Offices, and Preparator's Workroom to Collections Storage.

#### Fire Protection Systems

- Replace all Halon and FE-25 fire suppression systems in both 1932 Building and Hiatt Wing collections storage areas with a new water misting system with central equipment located in Mechanical Room MB22.
- Install new VESDA fire detection systems in all collections storage areas. Installation to have a four zone unit to serve basement storage areas and a two zone unit for Hiatt Wing storage areas.

#### Electrical & Lighting Systems

- Provide appropriate new LED lighting in all collections storage rooms.
- Provide power from existing electrical load centers for all new HVAC units, all new fire suppression and detection equipment, new LED lighting and required convenience power receptacles in collections storage rooms.
- Provide code conforming fire alarm systems in all collections storage rooms.
- Provide wireless data points to adequately cover all collections storage areas with wi-fi.

#### Collections Storage Equipment

- Provide all new 3D object storage shelving on compacting mobile carriages in North Storage and Objects Storage
- Provide all new painting screens in North Storage and Hiatt Crate Storage. Screens to be suspended from an overhead grillage supported on posts supported by the storage room floors.
- Provide new mobile carriages in Textile Storage for installation of existing cabinets from Textile Storage and Objects Storage. Provide new mobile carriages with shelving or cabinets to fill any remaining storage space in room.

The scope of work generally described above is described in detail in the body of this report.

#### **Cost & Phasing**

It is anticipated that the work described above will be accomplished in a phased manner each storage room improvement being undertaken as a single project. The project budget cost chart below reflects that assumption.

Storage Area	Construction Cost	Storage Equipment Cost	Soft Costs & Contingency @ 50%	Total Project Cost
Hiatt 2nd Floor Crate Storage	\$215,590.00	\$89,900.00	\$152,745.00	\$458,235.00
Textile Storage	\$307,940.00	\$90,000.00	\$198,970.00	\$596,910.00
Objects Storage	\$314,390.00	\$112,500.00	\$213,445.00	\$640,335.00
North Storage	\$712,205.00	\$333,900.00	\$523,052.00	\$1,569,157.50
East Storage	\$257,440.00	NA	\$128,720.00	\$386,160.00

#### **Additional Recommendations**

In addition to the work described above, which will increase the efficiency of the storage rooms, the Museum is in desperate need of additional storage space. A factor contributing to this need is the difficulty of preparing the PDP Storage area in the Hiatt Wing for compact mobile storage. In addition to the deficiencies in the exterior wall construction, the floor construction in the room has a 125 lb/sf load capacity and most likely a very low resistance to deflection under load. Loading in works-on-paper storage areas utilizing dense compact mobile storage should have a minimum capacity of 200 lb/sf and a very high resistance to deflection. The difficulty of achieving this in the existing storage room suggests that an alternate location should be found.

One such possible location for both PDP storage and possible expansion of other collections storage is the 1932 basement space presently housing the Photo Studio, Registrar's Offices, and the Preparator's Workroom. This space is contiguous to other collections storage spaces, is located in a highly environmentally stable part of the Museum complex, and was designated as collections storage space on original building construction documents. Further investigation of this option is recommended.





## Study Background and Process

**Study Background** With plans for a capital campaign under development and a continuing wish to improve collections storage conditions within the museum, the Worcester Art Museum applied for a NEH – Sustaining Cultural Heritage Collections planning grant to develop a Collections Sustainable Storage Initiative (CSSI) and to update the Collections Storage Improvement Study prepared by Solomon+Bauer+Giambastiani Architects Inc (SBGH) in 2004. In preparation for the grant application, Worcester Art Museum Chief Conservator Rita Albertson, and Registrar Joe Leduc attended a Sustainable Preservation Practices workshop presented by the Image Permanence Institute (IPI) in Chicago Illinois in November of 2012. They were joined at the workshop by SBGA staff members Larry Bauer, Stewart Marshall, and Karin Aslaksen. Approaches to the sustainable preservation discussed at the workshop became the basis of the Museum's successful grant application resulting in a grant award in 2013. Particular emphasis was given to updating 2004 recommendations for improvements to HVAC, fire detection, fire suppression, and lighting systems to assure the provision of highly sustainable, energy efficient, code conforming environments in collections storage areas.

### **Project Team** Worcester Art Museum

Led by Chief Conservator and Project Director Rita Albertson, the Worcester Art Museum Project Team included:

- Matthias Wascheck, Museum Director
- Tracy Caforio, Deputy Director and COO
- Jon Seydl, Director of Curatorial Affairs and Chief Curator
- Gareth Salway, Head Registrar / co-Project Registrar
- Matthew Manninen, Associate Registrar / co-Project Registrar
- Philip Klausmeyer, Conservation Scientist
- Francis Pedone, Director of Operations
- Nora Maroulis, Director of Philanthropy
- Trip Anderson, Grant Officer
- Mary Raskett, Budget Manager
- Steve Sandstrom, Museum Electrician

Participants in the early phases of the project who left the Museum before project completion include:

- Joe Leduc, former Registrar
- Susan Stoops, former Curator of Contemporary Art

### Interdisciplinary Consultant Team

Led by Larry Bauer of Solomon+Bauer+Giambastiani Architects Inc, the team included:

- Henry (Hank) Anthony, Exergen BSD - Environmental Systems Engineer

- Jason S. Der Ananian P.E., Simpson Gumpertz & Heger Inc - Building Enclosure Consultant
- Nicholas Artim, Heritage Protection Group – Fire Protection Consultant
- Kevin Murphy, Thompson Engineering – Electrical Engineer
- Jim Cole, Cole Contracting Inc – Cost Consultant

#### Image Permanence Institute

Jeremy Linden, Senior Preservation Environment Specialist at IPI providing assistance at the beginning of the Project in a two day consultation with the Museum. During the consultation Jeremy discussed the goals of the study with the Project Team, instructed Museum staff members on the use of the equipment and data analysis software, and coordinated the placement and installation of dataloggers

### **Study Process**

#### Data Gathering

To provide a base line for improvements to collections storage environments, the grant provided for the purchase of 30 IPI PEM2 dataloggers and eClimateNotebook software for recording and analysis of the data from the dataloggers. At a Project kickoff meeting in April 2014, Jeremy Linden of IPI met with the WAM and Interdisciplinary Project Team to discuss project goals, and coordinate appropriate locations for dataloggers to gather information required by the team for the study. Jeremy also met with members of the WAM project team to instruct them in the use of the EClimateNotebook software and in the process of downloading and saving data for analysis. On the following day he worked with members of the WAM project team to install dataloggers in selected locations and confirm their functionality.

#### Data Analysis

Requiring a full year of data for analysis of how the environment in collections storage spaces reacted to outside weather conditions over all four seasons, project activities went into an inactive period with members of the WAM and Interdisciplinary Project Team logging into EClimate Notebook from time to time to check the data being gathered and stored by the dataloggers.

#### Scope Development

Project activities picked up in late spring of 2015 with a Project Team meeting to review the year's-worth of data collected and to discuss the implications of the findings for recommendations to be made by the consultant team for improvements to the collections storage spaces and environments. Data logger information generally showed a very stable and slowly changing environment in the basement rooms of the 1932 building (spaces with little or no circulating air and no fresh air), and a stable but less consistent environment in the Hiatt Wing storage rooms (where deficiencies in the exterior wall construction require a much more active HVAC system to keep environmental conditions stable). Discussions centered mainly on the temperature and relative humidity ranges that the Museum desired to keep in its storage rooms, preliminary thoughts on

what types of changes were needed to the envelopes of the 1932 building and Hiatt Wing, and what type of HVAC system would be most practical to install to meet building code ventilation requirements in the basement storage rooms of the 1932 wing without compromising its very stable environment.

#### Storage Needs & Space Review

Associate Registrar Maat Manninen reviewed the Museum acquisition and deaccession records for the 2004 to 2015 time period to determine the amount of collections growth since the 2004 report. Figures indicated that because of deaccessioning (particularly of furniture) the actual volume growth in 3D collections is probably quite small. A much larger growth occurred in 2D works, particularly in works on paper. Because these objects tend to take up much less room, the volume of space required for their storage was small. Even so the growth in PDP collections is noticeable in the amount of additional collections stored on work surfaces within the PDP storage area.

Tours of other storage rooms revealed actually less crowding than was present in 2004. The improvement was attributed to much better organization of collections, purchase of some additional storage equipment, and the relocation of some collections to off-site storage facilities.

The 2004 study reported a need for about 10% more storage space to house the then existing collections in mobile compact storage in ideal storage conditions. The Museum's desire to bring back collections from expensive and inconvenient off-site storage and the expected move of some collections from galleries back into storage will again result in more overcrowding. In addition, the conversion of East Storage (designated as a swing space and overflow space for collections storage in the 2004 report) to dedicated storage for the Higgins Armory Collection has removed a safety valve for collections overflow. Additional space within the Museum must be identified to prevent deterioration of storage conditions due to overcrowding.

#### Project Recommendations & Scope of Work

Another team meeting in October produced consensus on environmental standards to be maintained in the storage rooms, on the treatment of the exterior walls of the 1932 Building basement storage spaces, on practical improvements to the exterior walls of storage rooms in the Hiatt wing, and on an approach to bringing ventilation in 1932 Building basement storage rooms up to building code standards. The Museum desired climate standards were set at a constant 50% relative humidity  $\pm 3\%$  and temperature fluctuating seasonally between 72°F and 65°F. The consultant team then prepared reports on the required changes in Building Envelope, HVAC Systems, Electrical Systems, Fire Protection Systems, and Collections Storage Equipment needed to achieve the desired improvements to storage of the Museum's collections.

Utilizing the information in the consultant reports, SBGA prepared a Scope of Work document detailing the work required in each storage area.

#### Conceptual Project Budget

To develop a budget for the recommended improvements, WAM contacted Jim Cole, the President of Worcester based Cole Contracting, Inc., a firm that has done most of the construction work at the Museum for the past 20 years. The consultant team supplied the written scope of work and drawings and reports describing details of the construction work and new MEP systems to Cole Contracting. A meeting and walk-through of the construction areas was arranged for early December. Attendees included Jim Cole, Kevin Murphy of Thompson Engineering Inc, Hank Anthony of Exergen BSD, Larry Bauer of SBGA, Fran Pedone, the Museum's Director of Operations, and an HVAC subcontractor.

At subsequent meetings and walkthroughs, Jim Cole and Fran Pedone met with subcontractors representing other trades required by the work. Based on the meetings and documents prepared by the consultant team, Cole Contracting and its subcontractors developed the construction cost estimate included in Section E of this report.

The budget estimate for collections storage equipment was developed by Larry Bauer of SBGA based on similar collections storage projects put out to bid by SBGA in the past five years. Figures for soft costs and contingency were taken from similar recent projects in which SBGA has been involved.



## Existing Collections Storage Conditions

**General** Although WAM has been unable to implement many of the higher cost, long-term recommendations for collections storage improvements contained in SBGAs 2004 study, major improvements have been made in the storage rooms. Through better organization of collections, rehousing of many objects, purchase of small amounts of high quality collections storage equipment, de-accessioning, and relocation of some collections objects to off-site storage; safety of and access to collections has been drastically improved. Overcrowding has been significantly reduced although as the photos of collections areas illustrates, it has not been eliminated entirely. The desire to reduce or eliminate off-site storage and the return to storage of collections objects presently on exhibition in galleries will also increase overcrowding in the existing storage rooms.

Collections growth of 3D objects has been relatively slow with the exception of the Higgins Armory Collection and the combination of deaccessioning and relocation to off-site storage has largely mitigated any impact from growth. The largest area of growth has been in 2D collections, especially in works on paper. These works tend to take less space, and reorganization of the PDP Storage Room has absorbed a portion of the growth. The number of solander and other boxes now residing on work surfaces attests to the problem that PDP Storage is having with its growing collection.

In terms of physical changes to collections storage areas, new lighting of a basic nature has improved lighting in the basement storage rooms, and new FE-25 fire suppression systems have been added in Hiatt Second Floor Crate Storage and in East Storage.

One major expansion of the collections did precipitate a major collections storage improvement project since the 2004 report. The Museum receipt of a large portion of the collections of the Higgins Armory Museum in Worcester which closed its doors at the end of 2013 posed an immediate need for additional space to house the collection. To meet the challenge posed by the acquisition of a large number of objects, the Museum renovated the former Museum Gift Shop Storage Space adjacent to North Storage in the 1932 Building basement to store the portions of the Higgins Armory Collections that were not put on exhibition. The Museum was able to relocate a significant portion of the very high quality Montel mobile compact storage equipment from the Higgins Armory Museum to the new (East) storage room resulting in a high quality storage space. Replacement of the fan coil unit and attendant piping located in East Storage along with a stand-alone humidification system is part of the scope of work recommended in this report, as is installation of a water misting system for fire suppression and a VESDA system for fire detection.

**Basement Storage Rooms** Other basement storage rooms (North, Objects, and Textiles) still rely on basically the same MEP systems that they did in 2004. Basic characteristics of these rooms are as follows:

#### North Storage

- In-room wall mounted non-ducted recirculating air handler with humidifier. No outside air. Now non-operational.
- Halon fire protection system.
- Standard smoke detector system.
- Exposed tube fluorescent lighting, some in inappropriate areas (over parked painting screens)
- Some fixed wooden storage shelving and racks. Some fixed metal shelving. Almost inoperable 1932 vintage painting screens.
- A small new installation of mobile lateral painting screen type racks for spears and other pole-like objects (from Higgins Armory)
- Sheet steel doors that are difficult to gasket effectively.
- Numerous unsealed penetrations of pipes, ducts, and wires through walls and floor slab above.
- Numerous abandoned ducts pipes, conduit and wires, mostly at ceiling but some on walls.

#### Textile Storage

- Floor mounted non-ducted recirculating air handler with humidifier located in corridor outside of room. No outside air.
- FM-25 fire protection system.
- Standard smoke detector system.
- Exposed tube fluorescent lighting
- Fixed wooden storage shelf at upper room perimeter. Some fixed metal shelving. A good amount of museum quality powder coated metal cabinets and flat files. Metal roll storage racks.
- Sheet steel doors that are difficult to gasket effectively.
- A small number of penetrations of pipes, ducts, and wires through walls and floor slab above.
- A small amount of abandoned ducts pipes, conduit and wires, mostly at ceiling but some on walls.

#### Objects Storage

- No HVAC system. Stand by residential dehumidifier.
- Halon fire protection system.
- Standard smoke detector system.
- Exposed tube fluorescent lighting
- Some fixed metal shelving. . A good amount of museum quality powder coated metal cabinets.
- Sheet steel doors that are difficult to gasket effectively.
- A small number of penetrations of pipes, ducts, and wires through walls and floor slab above.
- A very small quantity of abandoned ducts pipes, conduit and wires, mostly at ceiling but some on walls.

**Hiatt Wing Storage Spaces**

Hiatt Wing storage areas remain basically as they were in 2004. Deficiencies in the design and construction of the Hiatt Wing exterior wall need to be addressed either locally or globally if maintenance of a collections preservation environment in the wing is a long term goal. As suggested in the Simpson Gumpertz & Heger report in Section D, the best but most expensive solution is removal of the exterior limestone cladding and installing a proper air barrier and insulation in the cavity before replacing the cladding. Less drastic solutions undertaken from the building exterior are less likely to be effective, but can result in an improvement for localized areas. This approach has been recommended in the Hiatt Second Floor Crate Storage area.

The floor load capacity of the floor slab is 125 lbs per square foot. The deflection criteria used in the floor design is not known but is not expected to be robust. Because mobile compact storage of works on paper can easily exceed 200 lbs/sf, the floor would have to be strengthened to accommodate such a scenario. It may be more appropriate to re-locate PDP Storage to another area of the Museum.

The Hiatt Wing is served by multizone AHU-3 which supplies code conforming and humidity controlled fresh air to building spaces and has both gas phase and fine particulate filtration. This unit is being well maintained and there are no plans to change its operation or replace it.

The installation of FE-25 fire suppression systems in the Museum is a reasonable code-conforming solution to replace existing Halon Systems but may not be the best fire suppression system for the future. The Heritage Protection Group report in Section D discusses the pros and cons of multiple system, but highly recommends the installation of a water mist system in the storage areas.





## Improvement Recommendations

**General** In making recommendations for collections storage improvements, the multidisciplinary consultant team has largely concentrated on improvements in existing storage areas. The study leading into the recommendations has during the process uncovered conditions that may warrant a closer look at the overall collections storage strategy during a Museum Master Planning process. These conditions include:

- Difficult Access to Basement Storage Areas
- Building Envelope Deficiencies in the Hiatt Wing
- Floor Load Capacity Issues for Heavy Storage in the Hiatt Wing
- Need for Additional Storage Space for Future Collections Expansion

This study, rather than looking at these overall Museum planning issues (more suitable to a Museum Master Plan) has concentrated on improving collections storage environments and access, and wherever possible, increasing storage capacity in existing storage rooms. In looking at these issues, every attempt has been made to find solutions that will be sustainable over the long run and will reduce energy usage by the Museum. Because the 1932 Building Basement collections storage rooms have minimal or no HVAC systems and are not supplied with code required fresh air, energy usage for these areas will increase. New air circulation systems and the introduction of fresh air to the spaces will result in better air quality and the chance to remove products of building material and collections off-gassing from the spaces by better filtration.

The one exception to recommendations for reuse and improvement of a collection storage space is the PDP Storage Room in the Hiatt Wing. The floor load capacity issues for this room (if storage capacity were to be increased by the introduction of compact mobile storage equipment) make it desirable for the Museum to find an alternative location for PDP Storage. It has also been suggested that this space might be better used for gallery space because of its easy access to the public and location adjacent to other galleries. One possible re-location alternative is the existing Photo Studio and Registrar's Office Area adjacent to the Museum's other collection storage areas in the 1932 Building basement. This area and the adjacent Preparator's Workroom was originally designated for Collections Storage when the building was designed. These two areas could provide enough additional storage to house both PDP Storage and storage for collections expansion if a suitable location can be found for the present uses.

**Scope** Recommendations for improvements to Building Construction and Envelope, MEP Systems, and Collections Storage Equipment have been made for the following collections storage rooms:

### Hiatt Wing

- Second Floor Crate Storage

#### 1932 Building Basement

- North Storage
- Objects Storage
- Textile Storage

Recommendations for improvements to Building Construction and Envelope, and MEP Systems only have been made for the following space:

#### 1932 Building Basement

- East Storage

For reasons explained above, recommendations for improvements to the Fire Protection Systems only have been made for the following space:

#### Hiatt Wing

- PDP Storage

For each of the spaces listed above the following general scope of improvement has been recommended. Additional details can be found in the descriptions, reports, plans, and diagrams in this Section D of the study report.

#### Hiatt Wing Second Floor - Crate Storage

- Building Envelope Deficiency Mitigation
- New Fire Protection Systems
- New Lighting
- New Collections Storage Equipment

#### Hiatt Wing – PDP Storage

- New Fire Protection Systems

#### 1932 Building Basement – North Storage

- Insulation and Vapor Retarder Installation at Exterior Wall
- New Code Conforming HVAC System
- New Fire Protection Systems
- New Lighting and Convenience Outlets
- New Collections Storage Equipment

#### 1932 Building Basement – Objects Storage

- New Code Conforming HVAC System
- New Fire Protection Systems
- New Lighting and Convenience Outlets
- New Collections Storage Equipment

#### 1932 Building Basement – Textile Storage

- New Code Conforming HVAC System
- New Fire Protection Systems

- New Lighting and Convenience Outlets
- New Collections Storage Equipment
- Reuse of Existing Storage Equipment

#### 1932 Building Basement – East Storage

- Insulation and Vapor Retarder Installation at Exterior Wall (If lacking)
- New Code Conforming HVAC System
- New Fire Protection Systems

#### **Detailed Improvement Recommendations**

This Section D of the study report contains the following additional materials:

- Building Envelope Existing Conditions and Recommended Improvements – Simpson Gumpertz & Heger
- Conceptual Design Drawings for new HVAC Systems for the 1932 Building Basement – Exergen BSD
- Conceptual Design Drawings for new storage room lighting and electrical power for new HVAC and Fire Protection Systems – Thompson Engineering Inc.
- Discussion of and recommendations for new Fire Detection & Fire Suppression Systems for all collections storage areas – Heritage Protection Group
- Conceptual Collections Storage Equipment Layouts for all collections storage rooms – Solomon+Bauer+Giambastiani Architects Inc.



## Building Construction & Envelope Improvements

Improvements in the storage rooms can generally be divided into two categories, those necessary to assure that the building can hold a collections storage environment and those required to accommodate new compact mobile storage equipment. Both will require some further investigative work.

Exterior walls in basement storage areas of the 1932 Building are of massive concrete covered on the interior by a wythe of brick. No leaks have ever been reported in these walls except for conduit penetrations carrying water from the exterior. The north wall in both East and North Storage is mostly below exterior grade. Modeling of this wall indicates that its surface can get cold creating a microenvironment if good air movement between the wall and adjacent storage equipment is not maintained. There is also a slight risk of condensation on the wall at portions of the wall that are above grade on the exterior. The wall also contains window opening that have been closed with CMU on the exterior side of the steel sash. The details of waterproofing, flashings, and other exterior coatings on the CMU infill is unknown. The interior side of the CMU appears to be uncoated. Further investigation of the construction of these infills is recommended. Installation of insulation and a vapor retarder/air barrier and an interior finish of GWB on metal studs is recommended for the interior of these walls. The exterior of the east wall of East Storage is completely above grade with window opening that have been closed with CMU and an exterior stucco finish. Again it is not clear if any waterproofing or flashings have been installed over the underlying CMU. The interior of this wall has been covered with GWB on studs and it is unclear if any insulation or vapor retarder is included in this construction. As this wall is exposed to exterior weather conditions, further investigation is required to determine details of both interior construction and window infill. Recommendations for insulation and a vapor retarder/air barrier are the same as for the north wall.

Exterior walls of the Hiatt Wing are known to have discontinuous insulation and no vapor retarder on the exterior side of the CMU serving as back-up for the limestone cladding. Investigation indicates that the interior of these walls is exposed CMU with no vapor retarder and that the GWB on metal stud walls that cover this construction in most places contains no vapor retarder or insulation. A continuous liquid applied vapor retarder/air barrier applied to the back of the CMU has been recommended for areas that will be renovated for collections storage. See SGH report.

In addition to work on exterior walls, improvement recommendations include sealing all air leaks from storage room identified by blower door tests performed before construction and retesting after construction.

Existing doors in basement storage rooms are of steel plate construction and are difficult to seal effectively against leakage. The scope of work includes replacement of these door with new gasketed hollow metal doors.

New compact mobile storage for 3D collections in the basement will require the installation of concrete topping over the existing slab. The existing basement floors have a granolith concrete topping installed over a wythe of clay tile. Investigation of the ability of this construction to support loads of mobile storage rails must be undertaken.

Removal of all abandoned ductwork, piping, conduits and wiring will also improve room appearance and facilitate installation of new systems.



26 October 2015

Lawrence Bauer, AIA  
Principal  
Solomon+Bauer+Giambastiani Architects  
75 Kneeland Street  
Boston, MA 02111

Project 140565 – Enclosure Consultation at Art Storage, Worcester Art Museum,  
Worcester, MA

Dear Mr. Bauer:

As you requested, we have evaluated potential options for upgrading the exterior walls of the Hiatt Wing and Renaissance building basement so that they are suitable for the conditions necessary for art storage. We understand that portions of the existing basement in the Renaissance building will be used for art storage and will be humidified to a constant 50% relative humidity (RH). The project intent is to insulate and cover over the existing foundation wall with interior finishes. In addition, you are concerned about the effect that the elevated humidity levels may have on the existing building enclosure. Additionally, the project intent is to renovate the art storage area in the print department and third floor of the Hiatt Wing.

This letter summarizes our review of background documents, discusses key issues that would need to be addressed in the design of the art storage enclosure, and provides conceptual options for envelope design given the increased interior humidity levels that will be required for the new building use.

## 1. BACKGROUND AND FIELD OBSERVATIONS

We met with you, Hank Anthony of Exergen, and Francis Pedone and Rita Albertson of Worcester Art Museum (WAM) on 15 May and 21 October 2015 at the above-named project to discuss the project objectives. We also reviewed the original building drawings for the Hiatt Wing building, prepared by Irwin A. Regent and Associates Inc., dated 6 April 1982, and for the Renaissance building, prepared by William Aldrich Architects, dated 22 April 1931 (latest revision 24 August 1931), to understand the existing exterior wall construction. Appendix A includes the reference details. The following summarizes pertinent information:

- WAM reports intermittent water leakage through the north storage foundation wall at conduit penetrations for the exterior lamp posts. WAM does not report other sources of water leakage through the foundation walls or floor slab.
- WAM recently infilled several existing light wells in the north storage foundation wall as part of the main entrance stair renovation project. The existing metal-framed windows remain in the openings; however, Mr. Pedone stated that they installed CMU in the rough opening outboard of the existing windows and structural fill.



- Detail 19/A-12 of the Hiatt Wing drawings shows a typical exterior wall cross section detail. The wall assembly consists of the following components (listed from exterior to interior):
  - 3-1/2 in. limestone
  - 1 in. air space
  - 2 in. insulation
  - 8 in. concrete masonry units (CMU)
  - 3-5/8 in. metal studs
  - 1/2 in. gypsum base with veneer plaster

Simpson Gumpertz & Heger Inc. (SGH) conducted an investigation of the Hiatt Wing in 1987, and our review of the investigation photographs and report shows that the wall assembly lacks an air barrier and vapor retarder. WAM also reports condensation and frost accumulation on interior surfaces of glazing and aluminum window and skylight frames throughout the humidified Hiatt Wing, particularly in the Conservation Laboratory and first-floor conservation, print study, and office spaces, during the winter.

- A majority of the north storage foundation wall is below grade; however, a portion of the wall extends above grade. The above-grade portion of the wall assembly is clad with limestone panels and granite band courses. We did not make probe openings in the foundation wall to verify the wall construction; however, our review of the original drawings shows a 2 ft-8 in. thick concrete wall with a 4 in. interior brick facing on the north elevation. The east and west foundation walls, which are exposed to light wells, are similar to the north elevation wall, except with 2 ft-4 in. thick concrete. The interior brick in the north storage room is painted where the wall is not concealed by other finishes.
- WAM recently completed a renovation to the east storage room and installed compact storage cabinets, insulation, and interior finishes over the concrete foundation wall and window openings. We are unaware of the specific insulation materials or details utilized at the exterior foundation wall or window infills.
- Based on our observations at the time of the site visit, interior partition walls between the future art storage space and adjacent spaces are typically masonry. There may be other wall types present that are currently concealed by interior finishes.

## **2. DESIGN PARAMETERS AND BACKGROUND**

### **2.1 Design Parameters**

We understand based on our recent correspondence that the art storage space at WAM will operate under elevated interior RH levels during the winter months and that the mechanical system will be designed to maintain the following conditions:

- Summer: 72°F and 50% RH
- Winter: 66°F and 50% RH

For winter design conditions setpoints of 66°F/50% RH, the corresponding indoor air dewpoint temperature is 46.9°F. The building enclosure must be designed to maintain all surfaces, both interior and interstitial, that are exposed to indoor humidity above this temperature. In addition, the building enclosure, in conjunction with the mechanical system, must be designed to ensure that moisture-laden indoor air does not flow within or across the building enclosure where it can condense.

The risk of condensation caused by the migration of indoor water vapor from the storage areas into or across the building envelope is dictated by the design and detailing of the thermal, vapor, and air barriers in the existing building envelope (which are discussed below), and by the mechanical systems.

## **2.2 Thermal Barrier, Vapor Retarder, and Air Barriers Design Principles – Exterior Walls**

The thermal barrier is vital for maintaining the artwork in a stable interior environment, for energy efficiency, and for the prevention of condensation within walls. The thermal barrier should be installed continuous and thick enough to prevent condensation from forming on interior surfaces, particularly at exterior walls exposed to seasonal temperature fluctuations. In addition to insulation (thermal barrier), building enclosures in cold climates generally require a vapor retarder to control condensation due to vapor diffusion, as well as a continuous air barrier to prevent condensation due to air leakage. The vapor retarder should be installed on the warm side of the insulation to control the amount of vapor that diffuses through the insulation and into colder building materials in the envelope assembly. The air barrier must be continuous and sufficiently rigid to withstand air pressures exerted on it by a combination of stack effect, mechanical pressurization, and wind (the effects of wind and stack pressure are negligible for the basement art storage area). The air barrier is intended to restrict warm, moist interior air from flowing across the enclosure (exfiltration) and reaching colder surfaces near the exterior of the enclosure.

To be effective, the air barrier must be continuous, particularly at the following locations in the basement art storage rooms:

- Intersections between the wall and the ceilings, floors, and foundations, or between different wall and ceiling types.
- Interfaces of the wall system, doors, and windows.
- Penetrations where structural, mechanical, or electrical components penetrate or otherwise interrupt the air barrier.
- Joints and seams between sheets or boards that make up the air barrier.

The amount of condensation potentially formed within an enclosure assembly due to air leakage is generally much greater than that caused by vapor diffusion, particularly in buildings with humidified interior environments. The problem is exacerbated when the mechanical system is balanced to create positive air pressure on the interior of the building, as is usually the case in museums and art storage facilities.

The Hiatt Wing exterior wall assembly lacks a dedicated air barrier and vapor retarder and is at higher risk of air leakage through and condensation within the exterior wall assembly (behind the limestone veneer) during periods of cold weather. Our review of the investigation photographs shows that the CMU contains voids in the field of the wall and at intersections with structural steel framing (Appendix A). We do not know the extent to which interior air exfiltrates the wall assembly during the winter and condenses behind the cladding. For these reasons, we do not consider the Hiatt Wing wall assembly as well-suited for maintaining a humidified interior, unless a dedicated air barrier and vapor retarder is installed within the wall assembly. Removing the interior gypsum wallboard and steel stud framing and installing a continuous fluid-applied, vapor-impermeable membrane on the CMU, that integrates with the fenestration, penetrations, and floor assembly, is an acceptable approach to addressing this issue from the interior. The success of this approach depends on the access to the interior side of the CMU at partitions and transitions to maintain a continuous air barrier/vapor retarder.

A more reliable and costly approach is to remove the exterior limestone veneer and insulation to install a continuous air barrier membrane over the outboard side of the CMU, and integrate the membrane with the fenestration, roof assembly, etc. Providing a continuous air barrier/vapor retarder from the exterior side of the CMU is less disruptive to the museum's operations than installing the membrane from the interior.

### **2.3 Isolating Basement Art Storage Areas from Adjacent Spaces with Air Barrier**

We are assuming that the basement art storage rooms are the only areas that will operate under elevated RH levels. In addition to designing and detailing modifications to the general exterior enclosure to control moisture movement, the storage areas of the building must be isolated from the rest of the building. All interior construction (including solid masonry and other partition walls) that separates a storage area from adjacent spaces must be detailed to prevent air leakage. This will allow the mechanical system to control the storage area air pressure more easily, and will prevent humidified air from migrating into adjacent spaces.

Dedicated air barriers must be provided in the art storage spaces to separate them from the other parts of the building and those with different interior operating design conditions. The continuity of the air barrier must be maintained along the entire perimeter of the climate-controlled area, both in plan and in section. The following examples illustrate locations that need to be detailed for air barrier continuity:

- **Ceiling/Wall Intersection** – A dedicated air barrier must be maintained at the transition between the wall and the ceiling to prevent air from migrating between the art storage and adjacent spaces.
- **Floor/Wall Intersection** – all interior walls that separate a climate-controlled area from an adjacent space must be sealed airtight to the interior floors they intersect. The bottom of the walls must be sealed to the floor, and the top should be sealed to the underside of the ceiling.
- **Doors** – all doors leading into the storage space from adjacent interior spaces must be gasketed to reduce air leakage.

- **Air Shafts** – humidified air from the storage spaces must not be allowed to migrate into vertical shafts that will draw and disperse air into other floors by stack pressure.
- **Other Penetrations** – all mechanical, electrical, and plumbing components that penetrate the walls and floors in the climate-controlled areas must be sealed (i.e., smoke sealed) to prevent air leakage between adjacent spaces.

### **2.3.1 Material Selection for Vapor Retarders, Thermal Barriers, and Air Barriers**

A sheet material, such as polyethylenelene or aluminum foil, can be an acceptable vapor retarder when installed inboard of the insulation. However, these materials are not normally effective air barriers because they are not rigid, and are difficult to seal permanently to components that penetrate the barrier, such as beams, partition walls, electrical outlets, mechanical ducts, plumbing, and fasteners. Air barriers installed outboard of the exterior sheathing or CMU are generally more continuous and easier to install in an airtight manner because there are fewer obstructions. For historic mass masonry walls such as those in the Renaissance building, this is not typically practical without significant wall reconstruction. Solid masonry walls are rarely effective air barriers by current standards.

Closed-cell spray-applied polyurethane foam (ccSPF) insulation functions as an effective air barrier, thermal barrier, and vapor retarder if it is continuous, of uniform thickness, and well adhered. Additionally, rigid board sheathing materials, such as wallboards and plywood, can function as effective air barriers, but all joints must be taped and sealed. The existing exterior walls at the Renaissance building do not include a dedicated vapor retarder, thermal barrier, or air barrier.

### **2.4 Water Leakage through Foundation Wall, Basement Windows, and Floor Slab**

Water leakage through the existing foundation wall, basement windows, and/or floor slab must be addressed in addition to properly designing and installing an air, vapor, and thermal barrier for the main art storage space. WAM is aware of ongoing problems through the exterior lamppost conduit penetrations through the north storage foundation wall; however, we understand that the remainder of the proposed art storage area currently does not experience water leakage. WAM must institute a maintenance program to keep the building reasonably watertight, especially in areas that do not have below-grade waterproofing.

### **2.5 Existing Windows in Basement Art Storage Rooms**

Our conceptual sketches assume that the wall behind the existing windows on the east elevation can be permanently infilled, as it is not necessary for the existing windows to provide natural light into the art storage spaces. The existing window openings are currently infilled; however, the construction of the infill panel is unknown. The north elevation art storage window openings are infilled with CMU and the light wells are closed. Infilling the walls allows a complementary thermal, air, and vapor retarder to be installed and also allows us to provide a back-up waterproofing system.

### **2.5.1 Preservation of Artwork and Exterior Wall Design**

Preservation of artwork requires sufficient air flow around the objects to provide a constant climate around them. When artwork or storage crates are placed against exterior walls, they effectively become part of the wall system and prevent moisture between the wall finish and the artwork from drying. The air spaces behind and within the artwork contribute to the wall's thermal resistance; they become insulators and, as such, a temperature drop occurs across the storage unit which can damage the objects. Even with heavily insulated walls, storage units placed against the wall contribute to the wall's thermal resistance and are subject to a temperature drop. Therefore, artwork or storage units should be kept away from exterior walls, and sufficient climate-controlled air circulated around the collection.

Alternatively, artwork or storage units can be placed closer to exterior walls if the surface temperature of the wall is maintained at interior conditions. This can be achieved by designing the exterior wall as a double wall system, such that interior air is circulated behind the wall surface against which the artwork is stored.

## **3. CONCEPTUAL DESIGN OPTIONS**

The following two concepts are below-grade wall design options for the Renaissance building art storage space. Variations in the type, thickness, and sequencing of materials can have a significant effect on the wall's moisture performance. These options address the potential for ongoing or future leakage through the foundation walls.

The descriptions of building enclosure options for the below-grade art storage spaces listed below are only conceptual; they are suitable for discussing and comparing options, but they are not sufficiently developed for bidding and construction. Additional design and detailing is necessary before these options could be implemented on the building.

Regardless of which option you elect to pursue, we recommend the following:

- Remove and temporarily store all existing frames and sashes. Replace the broken glass and replace all damaged glazing or hardware materials. Infill all window openings with CMU flush with the interior surface of the foundation wall. Install a self-adhering membrane (SAM) water-resistive barrier/air barrier/vapor retarder membrane on the exterior CMU surface and integrate the SAM with a metal through-wall flashing at the sill. Protect the SAM from UV exposure with a cladding material, such as stucco, metal, or painted sheathing.

The SAM will prevent warm, moist interior air from migrating through the window opening and condensing on cold window frame/glass surfaces during the winter. Additionally, the SAM will prevent any water infiltration through the existing windows from leaking to the building interior and damaging artwork. We illustrate a conceptual window repair in Sketch SK-1, dated 26 October 2015.

- Consider installing a trench drain at the base of the north art storage foundation wall. This would allow any groundwater penetrating the wall to drain freely into a trench drain cut into the existing floor slab, which reduces the risk of water leakage to the wall assembly and art storage space. The trench drain should connect to a sump pump or

under-slab drainage system. Given that WAM stated the foundation walls do not leak, except for isolated locations at the lampposts, a trench drain may not be necessary, depending on the level of risk WAM is willing to accept. Repair the lamppost conduit penetrations to mitigate water leakage through the foundation wall.

- The interior wallboard product should not contain paper facers, as these provide nutrients for mold growth. Fiberglass-faced gypsum boards or similar products should be used to reduce the potential for mold growth in damp, basement conditions. A 1/2 in. gap should be provided between the base of the wallboard and the floor to prevent moisture that may accumulate on the floor from wicking up the wallboard. The gap should be filled with backer rod and sealant to maintain the air barrier.
- All mechanical, electrical, and plumbing components that penetrate the wall system must be detailed to provide a continuous air barrier, including lighting fixtures, electrical conduits, mechanical ductwork, pipes, etc. Typically, this is achieved by installing a combination of smoke seals, airtight electrical boxes, uncured EPDM membrane transition flashing, and sealant at penetrations.
- Preservation of artwork requires sufficient air flow around the objects to provide a constant climate around and within the objects. This requires that storage units placed near the floor have an air space at the bottom to allow conditioned air to circulate freely around the objects
- Do not use vapor retarding wall finishes (i.e., vinyl wallpaper) on the interior surfaces of the exterior walls. We recommend using breathable paints such as acrylic latex paints with a minimum permeability of five perms.
- Given the history of isolated water leakage into the basement, use galvanized metal framing to construct interior enclosures.

The options for the below-grade walls are:

### **3.1 Option 1 – Add Interior Enclosure with Separate Dry Air Blown into Cavity (Preferred Option)**

Store the collection(s) in a separate enclosure that has an independent climate control system. Build an independent enclosure within the existing space, with its own separate mechanical system. We illustrate this concept in Sketch SK-2, dated 26 October 2015 and summarize the concept below:

- Provides for two climate-controlled areas: one that is suitable for collection storage and another that is suitable for the existing exterior walls. An interior enclosure that is sealed airtight to the floor and ceiling is built adjacent to the exterior walls, and dry air at room temperature is blown into the cavity between the interior enclosure and the existing wall.
- Reduces the condensation potential on and within the exterior wall because dry air is in contact with the existing wall. Collections can be placed closer to the walls of the

interior enclosure because the surface temperature of the interior enclosure is constant.

- Relatively expensive design because it requires separate mechanical systems for the interior air and cavity air. The cost increment is decreased if the existing mechanical system can be used for the wall cavity.
- The cavity between the interior enclosure and the exterior wall needs to be sufficiently wide to accommodate supply and return air ducts; ideally this cavity could be wide enough to access the existing exterior walls for inspection and maintenance. An air barrier, thermal barrier (mineral wool insulation), and vapor retarder are also required between the interior enclosure and the existing wall to control outward air flow, heat transfer, and vapor diffusion, and maintain the interior environment at the desired humidity level. The interior gypsum wallboard can function as a reasonably effective air barrier if all joints and penetrations through it and all terminations are sealed.
- Unlike Option 2, the interior enclosure is constructed from non-combustible materials and does not contain foam plastic (ccSPF).

### **3.2 Option 2 – Insulate the Interior Side of the Foundation Walls and Build Interior Enclosure**

Insulate the inboard side of the existing foundation walls with closed-cell polyurethane foam (ccSPF) insulation from floor to ceiling and build an interior stud wall adjacent to the exterior walls. We illustrate this concept in Sketch SK-3, dated 26 October 2015, and summarize the concept below:

- The ccSPF insulation functions as the vapor retarder, thermal barrier, and air barrier for the wall system and provides sufficient control of winter and summer moisture drive from damaging moisture-sensitive interior finishes. Additionally, the ccSPF insulation is moisture-tolerant, continuous, and uninterrupted by steel studs (which can create thermal bridging).

The governing building code, 2009 International Building Code (IBC), includes a section that governs the use of foam plastic in buildings. We did not perform a comprehensive code review, but in our limited review noted that Chapter 2603.4 requires that foam insulation be separated from the interior of a building by an approved fire barrier of 1/2 in. gypsum wallboard or equivalent thermal barrier material, complying with ASTM E119. Additionally, combustible concealed spaces shall comply with Section 717 [of the 2009 IBC]. We have had projects where the authority having jurisdiction will not accept the interior gypsum wallboard attached to the metal framing because an air space is created between the insulation and the wallboard. Should this be the case on this project, the 15 min. thermal barrier can be provided by a spray-on cementitious fire protective coating for use over polyurethane.

- At the north foundation wall, the ccSPF insulation should be applied onto a drainage mat that is mechanically fastened to the existing foundation. Extend the drainage mat to the floor slab and connect to the trench drain as discussed in Section 3 above. Given the lack of known leakage through the foundation wall, except for isolated

locations at lamppost conduit penetrations which WAM intends to repair, the installation of the drainage mat and trench drain provides redundancy should any significant leakage occur through the foundation walls. Should the drainage mat and trench drain be omitted, apply the ccSPF insulation to a galvanized metal lath that is mechanically attached to the existing foundation.

We used THERM 7.3 Software by Lawrence Berkeley National Laboratories to perform a thermal analysis of the proposed insulated wall assembly with 1-5/8 in. galvanized light gage metal framing at 16 in. o.c. spaced 1/2 in. inboard of the interior brick masonry surface, 2 in. ccSPF insulation between steel studs and 1/2 in. interior gypsum wallboard, in order to understand the risk of interior surface condensation at the design conditions. The results show that the interior gypsum wallboard surface temperature is maintained above the interior air dewpoint temperature on the ASHRAE design day (Appendix C, attached).

- This option requires relocating or adding HVAC supplies to the perimeter to allow supply air to wash the exterior walls with conditioned air. Stored artwork may need to be placed at least 6 in. away from the wall (the space requirement depends on the velocity of the supply air), leaving sufficient space to allow supply air to circulate around the artwork and wash the exterior wall.
- A disadvantage of this option is the difficulty associated with inspecting the cavity space between the existing foundation wall and the new interior wall for wall damage, leakage, or other problems in the future.

### Field Testing

During construction, we recommend performing qualitative blower door testing of the basement art storage spaces, using tracer smoke to verify the efficacy of the air barrier, transition details, etc.

## 4. ART STORAGE HVAC DESIGN

To date, we have not received or reviewed HVAC design drawings or specifications prepared by Exergen. We will need to perform a review the HVAC design for integration of its working parameters with the exterior wall design and layout of art storage cabinets.

Sincerely yours,



Jason S. Der Ananian  
Senior Project Manager



Brent Gabby  
Senior Principal

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## HVAC Systems

The entire scope of HVAC System improvements will be directed at basement storage areas. Basement storage environments are quite stable but are often outside the parameters of the Museum's desired environmental standards. Three of the four storage rooms are served by stand-alone air-handlers, two of which are located within the storage rooms themselves with all their attendant piping. One of these two units is non-functional. One storage room has no HVAC system. All units recirculate air within their designated rooms without introducing fresh air to the spaces. None of the systems have distribution ductwork within the rooms.

To meet building code requirements for ventilation and to provide better air circulation within rooms, all existing units will be replaced with new air handler installed outside the rooms and feeding air supply distribution ductwork within the rooms. Each unit will be supplied with code required minimum fresh air from a new fresh air AHU unit located in basement Mechanical Room MB22. This unit will have the ability to provide humidified temperature controlled fresh air to the new local dedicated air handlers serving each room. The new fresh air AHU will have both gas phase and fine particulate filtration. Each local AHU will have a dedicated humidifier providing humidity to the supply air stream and carbon impregnated particulate filters to provide some gas phase air filtration.

The code required minimum fresh air volume will provide the storage rooms with approximately one air change per hour.



### **Electrical Power & Lighting Improvements**

In addition to providing electrical power to new HVAC and Fire Protection systems, the scope of Electrical Improvements will include the installation of new LED lighting, new code conforming fire alarm systems, and new wireless data points in collections storage areas. Adequate capacity exists in existing electrical distribution panels to take care of these needs.



## **Fire Detection and Suppression Systems**

Basement collections storage rooms North Storage and Objects Storage are presently equipped with Halon fire suppression systems and standard smoke detectors. Basement storage room Textile Storage is equipped with an FM-25 suppression system and standard smoke detectors. Basement storage room East Storage is presently equipped with a standard wet pipe sprinkler system. In the Hiatt Wing PDP Storage is equipped with a Halon fire suppression system and standard smoke detector while Second Floor Crate Storage is equipped with an FM-25 fire suppression system and standard smoke detectors.

The scope of improvement work will replace all fire suppression systems with a water misting system with equipment located in basement mechanical room MB22. All storage rooms will also be equipped with VESDA fire detection systems with basement storage rooms reporting to a four zone unit and Hiatt storage rooms reporting to a two zone unit.

# Heritage Protection Group

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## Fire Suppression Summary Artifact Storage Vaults Worcester Art Museum

### Introduction

The Worcester Art Museum is evaluating options to upgrade the automatic fire suppression system for their artifact storage vaults. This is an issue that museums often encounter since there is the underlying need to safeguard their collections but to do so with the least amount of harm. There are several options, each offering a set of benefits and detrimental side effects. The key is to select the system that offers the greatest benefit while minimizing residual harm.

For many years, the fear of water damage from traditional fire suppression tools, notably standard pressure fire sprinklers, led many institutions to select non-water, gas based agents. The earliest systems utilized carbon dioxide (CO<sub>2</sub>) that can be very effective, but is hazardous to human safety. Various chemical agents were developed and through this work, Halon 1301 emerged as a viable product. Halon 1301 is discharged into the protected space as a gas that uniquely suppresses fire by breaking the chemical process of fire and it does not leave residues, minimizing post fire recovery. Halon for many years represented an ideal fire suppression product for museum vaults and was widely used.

Halon was later found to be an ozone depleting substance that remains suspended in the atmosphere for many years. Consequently the production of Halon ceased along with numerous other ozone depleting agents as governments moved to reduce environmental harm. Halon may still be used, but replacement stock is increasingly more difficult to obtain and several service contractors have ceased support for these systems. This led to the development of newer gases that complied with environmental standards, and are marketed as “clean-agents”. This term however can be somewhat deceptive and the museum care community has recognized that there may be harmful byproducts (i.e. hydro-fluoric acid) when some of these agents are discharged in a fire condition. There may also be physical damage to collections when gases are discharged at high velocities into closed compartments.

Water remains an option that is readily available and does not harm the environment. However this presents another set of concerns, especially for artifacts that may be harmed by water application. In many instances there is recognition that if water is used for fire protection, there will be some level of content saturation and a loss that must be anticipated. Fire protection manufacturers have responded to this concern by developing more efficient water-based systems that control fires with significantly lower quantities of water.

In essence, when a fire becomes significant enough to require the operation of an automatic fire suppression system, there will be some level of damage. Therefore when selecting a fire protection system, the best choice will be that which responds quickly to control the incident before high levels or complete damage ensues. This is the issue that the Worcester Art Museum is currently facing.

### Fire Protection Objectives and Strategy

Fire protection is a multiple faceted discipline that encompasses fire prevention/risk management, fire detection and alarm, emergency evacuation, isolating the fire size, fire extinguishment, and emergency recovery. Various fire and building codes and standards address many of these issues, however the primary goal of most mandated documents is life safety, with little concern for property preservation or mission continuity. For the vaults at the Worcester Art Museum, fire protection must encompass occupant safety, property and mission protection. The general fire protection objectives for this site are:

- Protect Public Health, Safety and Welfare (Life Safety): A primary aspect of appropriate fire safety is to safeguard the visitors who occupy the building at a given time.

- Protect Employee Health, Safety and Welfare: Equally important is the need to safeguard the building's staff and responding firefighting personnel.
- Prevent Loss of Resources (Building): To minimize the impact on the building the fire should be confined to the specific room or compartment where it originates. Ideally this should encompass no more than one half of a floor level and not spread to adjacent floors. The building must not sustain irreparable structural failure (collapse) from a fire.
- Prevent Loss of Resources (Non-Collections Contents): Non-collections contents include office documents, furnishings, records and retail items. Damage to non-collections spaces should be limited to a maximum of a single floor area.
- Prevent Loss of Resources (Protecting Cultural Resources): The unique, rare or irreplaceable artifacts can be harmed by flames, heat and smoke. For museum storage spaces damage should not exceed approximately 50 m<sup>2</sup>.
- Provide Visitor Services and Educational Opportunities (Mission Continuity): If the building is damaged the educational and interpretive aspects of the building will at a minimum be temporarily stopped and at worst completely lost. Access to the building should be allowed within four hours to initiate damage assessment and protect/relocated those items that are undamaged. The building must be able to return to full operation within six months.

Accomplishing the desired protection objectives can be achieved by a multiple faceted approach that manages fire risk, limits fire spread, detects an incipient fire, notifies the building occupants, contacts emergency responders (security and the fire department), and provides fire extinguishment through manual and/or automatic methods.

- Risk management. A fire at a cultural heritage site can be devastating. Therefore the most important protection efforts need to focus on minimizing fire risk to reduce the chance of ignition, limit the combustibility of contents, and prevent the interaction of hot sources and combustibles. Risk management can be among the least expensive and most productive aspects of fire protection. Proper risk management encompasses those efforts that prevent the interaction of combustible materials (fuels) with ignition sources. Also known as fire prevention, this can be a relatively inexpensive aspect of a fire prevention program. It must be ongoing since hazards will change over time as fuel quantities may be altered and mechanical and electrical components wear to increase the ignition threat.
- Limiting fire spread is accomplished by the walls, ceilings and floors within the building. The construction type in the Worcester Art Museum is generally capable of confining a fire to the compartment of fire origination. Maintaining fire resisting features is also an ongoing effort since walls may settle, new openings may be made to install cables and mechanical systems, and doors can be left open. In all instances new openings should be repaired to maintain the necessary level of fire resistance.
- Detection and notification. If a fire starts, it is imperative that it be recognized as soon as possible, building occupants must be notified to safely evacuate, and emergency personnel contacted to respond. For most fires, the process commences with an ignition source and combustible coming in contact with each other. Usually this will result in a slow burning incipient (smoldering) phase that can last for several minutes to many hours. As the fire continues to develop the heat will gain intensity and eventually flames will appear and once this occurs, the damage will grow exponentially. For properties where high value items are housed, it is imperative that fire detection occurs during the incipient or irreparable damage will occur.
- Fire suppression. Once a fire has been discovered it must be extinguished. A relatively small fire may be extinguished with portable extinguishers but success is dependent on someone who knows how to use this extinguisher. They must respond before the fire is greater than approximately three feet in height, or the



extinguisher's capabilities will be exceeded and the fire department will then be needed. Automatic fire suppression, especially for significant properties will often be installed to control a fire and prevent fire migration until the fire department can arrive.

## **Fire Suppression Options**

For every fire suppression option it is important that efforts be made to identify the fire during its incipient (smoldering) phase before flaming combustion appears. The most effective detection choice for art vaults utilizes air-sampling technology and is commonly referred to by the brand name "VESDA". VESDA is often able to identify a developing fire at the earliest stage of combustion, frequently before visible smoke emerges. It can be designed to sample air at multiple levels, capturing the low buoyancy smoke that occurs during a fire's earliest stages. The present smoke detection system within the vaults should be replaced with VESDA technology that is connected to the building's fire alarm system.

There are several fire suppression options for the Worcester Art Museum vaults, with several attributes that need to be evaluated to arrive at the best choice. These include:

- Speed of response. Once a fire has started, there must be a rapid suppression agent release to stop the fire before it reaches devastating levels. Obviously the longer that the fire burns before suppression is attempted, the greater the loss. Gas agents controlled by smoke detection will often respond to a developing fire before thermal release water systems operate.
- Effectiveness. An early suppression agent release is only beneficial if it actually controls the fire. The selected agent must be appropriate for the type and geometric arrangement of combustibles within the space. Otherwise the agent will not add to the protection needs. This requires a careful understanding of the capabilities and limitations of the suppression agent since some agents can be very effective at initial release, but may not be successful if the fire becomes deep seated. This factor must be considered for the present storage, and possible changes that may occur in the future.
- Residual damage. Residual damage is the harm caused, not by the fire, but by the release of a specific suppression agent. For example, high levels of water may suppress a fire but may also saturate some materials so that they cannot be recovered. This is a recognized concern with standard pressure fire sprinklers. In other instances the agent may cause chemical damage that is readily apparent, or may be revealed long after the fire has been controlled. Also the discharge rate of many gas agents will cause physical harm to the room and its contents.
- Resistance to inadvertent discharge. It is important that the extinguishing agent release when the fire is developing, but equally cannot discharge if a fire is not present (false discharge). Systems that utilize thermal detection (i.e. sprinklers) will generally be more resistant to false discharge than smoke releasing systems (gases). With careful engineering and equipment maintenance, this concern can be reduced to a very low probability.
- Cost. The cost to install and maintain the system must be considered so that the system is properly installed and remains viable. The cost equation should also approximate post fire recovery costs for materials that may be damaged during fire system operation.
- Long-term durability and availability. An automatic fire suppression system is a large investment and therefore the selected system must be durable and last for a long time without major expenditures. For example a sprinkler system that uses conventional carbon steel pipe can have a shorter life expectancy than a similar system that uses stainless steel pipe. With respect to gas agents, the anticipated production duration should be evaluated since some gases are no longer available, and some of the replacements require extensive piping reconfiguration.
- Environmental impact. This is particularly relevant to gas agents where they may be currently acceptable but future availability is uncertain. For example, many of the current "clean agents" comply with present ozone

protecting standards. However recently establish global warming potential (GWP) issues are emerging as a new concern and this is leading to a re-evaluation of many of these gases. While this issue has not impacted gas choices in the United States, several European Union (EU) and Canadian governmental agencies are closely evaluating these gases and this will likely lead to further bans.

The following presents a list of available options and highlights key benefits and disadvantages of each.

1. Extinguishing Gas - FE-25. This option will utilize DuPont FE-25, which was developed as a drop in replacement for Halon and for the most part it is able to achieve this objective. FE-25 works by thermal decomposition and chemical interaction to cool the fire's reaction. Required gas concentrations range from 9%-12%.

The system will use the majority of the existing piping with nozzles changed as necessary. Storage cylinders will be replaced to house the new gas. Since concentration levels are higher than Halon, more cylinders will be needed.

Advantages of this option include:

- The continued use of most of the existing piping with minimal changes
- Lowest expected cost of replacement gas
- Approximate 35% increase in the quantity of stored gas agent which minimizes the need for increased storage space
- Negligible ozone depletion impact
- Minimal increase in room pressure
- Suppression without water residual damage
- Product is in production
- The ability to suppress shielded or hidden fires.

The main disadvantages are:

- There test data is mostly for small class A fires (i.e. waste basket). There is minimal information on suppression performance in large class A fire situations, i.e. library stack face fire.
- This is a zoned system with agent discharged throughout the entire space. It cannot be partially discharged
- Discharge velocity can physically damage items within the discharge path
- It is a single discharge system without backup
- The room integrity must be tight to prevent leakage and loss of suppression.
- The gas has a vapor density of 4.2 and it will migrate to lowest levels that may produce a high concentration at the lowest levels. Mechanical extraction will be needed
- Hydrogen fluoride production during suppression
- High GWP

2. Extinguishing Gas - FM-200. This option will utilize DuPont FM-200 extinguishing gas, which is among the most widely used Halon replacement gases. This gas works primarily by thermal cooling and chemical interaction with typical gas concentration of 7%-8%.

The system will require complete new piping since flow characteristics are different from Halon. Storage cylinders will be replaced to house the new gas. Since concentration levels are higher than Halon, more cylinders will be needed. As with Halon it is recommended that the detection system is upgraded.

Advantages of this option include:

- Widely used and available product
- Minimal added gas storage requirements

- Negligible ozone depletion impact.
- Minimal increase in room pressure
- Suppression without water residual damage
- Gases can generally suppress shielded or hidden fires

The main disadvantages are:

- Piping and nozzles will need to be replaced
- Data on large class A fires similar to library stack rooms is minimal.
- This is a zoned system, discharged throughout the entire space, and cannot be partially discharged
- Discharge velocity from nozzles can physically damage materials within the discharge path
- Single discharge system. If the fire is not controlled with the discharge there is not a backup
- The room integrity must be tight to prevent leakage and loss of suppression.
- Hydrogen fluoride production during suppression
- High GWP

3. Extinguishing Gas – Inergen. Inergen is a non-chemical gas which inertes the compartment atmosphere to lower oxygen concentration to a level that cannot support open flaming. These concentration levels are designed to allow a normally healthy person to continue breathing but can create difficulties for persons with cardio-respiratory problems. Design concentration is typically 35%-50%, which significantly increases room pressure. This must be properly vented to prevent wall and/or structural damage.

The system will require complete new piping since flow characteristics are different from Halon. Storage cylinders will be replaced to house the new gas. Since concentration levels are higher than Halon, more cylinders will be needed.

Advantages of this option include:

- Inergen is non-ozone depleting and therefore unlikely to be banned.
- The agent is composed of nitrogen, carbon dioxide and argon and does not cause chemical damage to collections
- Suppression without water residual damage
- Product is in production
- Gases can generally suppress shielded or hidden fires.
- No GWP

The main disadvantages are:

- This agent must be stored as a gas, unlike chemical agents that are stored under pressure in liquid phases. Consequently a large number of cylinders will be necessary and this will require a large amount of physical space to store the gas.
- It is a zoned system with extinguishing agent discharged throughout the entire space. It cannot be partially discharged.
- A very large quantity of gas must be injected into the room in a short time period. The discharge velocity will physically damage materials within the discharge path
- This is a single discharge system and does not have a backup.
- The room must be properly vented to prevent overpressure. Once discharged has occurred the room integrity must be tight to prevent leakage and loss of suppression capability.
- The gas has a vapor density of 1, which is comparable to air however it may migrate and produce an increased asphyxiation hazard. Mechanical extract is recommended.

4. Extinguishing Gas – Novec. Novec is a ketone-based fluid that is stored as liquid and utilizes compressed nitrogen to discharge the fluid into the fire compartment. This creates a high efficiency cooling process that

controls the developing fire. Discharge concentration levels are designed to allow a normally healthy person to continue breathing but can create difficulties for persons with cardio-respiratory problems. The system will require complete new piping since flow characteristics are different from Halon. Storage cylinders will be replaced to house the new gas.

Advantages of this option include:

- Approximate 35% increase in the quantity of stored gas agent which minimizes the need for increased storage space
- Negligible ozone depletion impact
- Minimal increase in room pressure
- Suppression without water residual damage
- Product is in production
- The possible ability to suppress shielded or hidden fires.
- Minimal GWP
- Expected long term production and availability of product.

The main disadvantages are:

- There test data is mostly for class B (flammable liquid) and Class C (electrical) fires. There is very little data on the effectiveness of the product on large class A (solid combustible) fires such as those encountered in an art storage vault.
- New piping and control equipment will be necessary
- This is a zoned system with agent discharged throughout the entire space. It cannot be partially discharged
- Discharge velocity can physically damage items within the discharge path
- It is a single discharge system without backup
- The room integrity must be tight to prevent leakage and loss of suppression.
- Hydrogen chloride production during suppression

5. Fire Sprinklers – Standard Pressure. Standard pressure fire sprinklers are currently used in the sub-basement mechanical spaces and are appropriate for the space.

This option will provide water sprinklers in lieu of gases. Sprinklers will be designed for the appropriate application densities for each space with densities ranging from relatively light 0.15 gpm/ft<sup>2</sup> for standard shelving and racked storage systems to higher 0.28 gpm/ft<sup>2</sup> for dense storage arrays. Most sprinkler systems are wet-pipe with pipes constantly filled with water so that water discharges upon sprinkler activation. However for the vaults a pre-action system that requires a sprinkler activation and a smoke detector to operate for water discharge is recommended. The recommended VESDA can be configured to serve as the pre-discharge smoke detection function.

Advantages include:

- The system is not a single discharge arrangement and will keep operating as long as desired.
- No environmental impact
- It is not a deluge system with each sprinkler individually activated.
- Recovery will be water related without a chemical impact from the gas
- No production or regulatory limitation on extinguishing agent
- Room integrity is not required
- Sprinklers can be designed to cool walls, ceilings and doors to prevent failure from fire
- High resistance to false discharge.
- Numerous product manufacturers and installation contractors.
- Probable lowest cost option.

Disadvantages include:

- Very high water application rates that will range from approximately 100 – 500 gallons per minute. This water flow can be expected for at least fifteen minutes until the fire department responds, completes extinguishment, and then shuts down the respective control valve.
- A large amount of water runoff to lower levels
- Electrical demand for pump (if needed)
- Standard pressure sprinklers cannot suppress a shielded or obstructed fire. These type fires will continue to burn until the shield burns away or manual fire suppression occurs.
- Extensive new pipe work will be required.
- A fire pump and associated control equipment may be needed. Space for the pump will need to be located.
- Nominal 35 – 50 year life expectancy
- Corrosion potential from improper drainage or dissimilar metals

If the standard pressure sprinkler option is chosen only the highest quality piping materials should be used to overcome some of the corrosion failures that have been found in some recent sprinkler systems. Using a clean water pipe such as stainless steel or copper tube is preferred.

6. Fire Sprinklers – High Pressure Water Mist. This option is similar to option 5 except the sprinkler system will utilize high-pressure water mist distributed through a network of stainless steel tubes and fittings. This is the UltraFog or Marioff Hi Fog system with each sprinkler operating by its own thermal sensing bulb so that only those sprinklers in proximity to the fire will operate. The system can be either wet pipe or pre-action similar to standard pressure systems. Pre-action is preferred for the Worcester vaults. Pressure is achieved by either a compressed nitrogen powered pump or an electric motor pump with the electric pump the likely best option for the museum.

Advantages

- This system has the lowest flow rate of any sprinkler system with approximately 10% of the water that is required for standard pressure systems.
- The system has extensive test data and is listed for a wide range of applications including protecting class A commodities
- It is not a single discharge arrangement and can keep functioning as long as desired
- Very low rates of water runoff
- Very low water saturation of contents
- Coverage per sprinkler is comparable to standard pressure systems
- The fastest responding sprinklers available
- It is not a deluge system with each sprinkler individually activated.
- The system has an ability to reach shielded fires.
- All tubing, fittings and nozzles are stainless steel resulting in a clean water discharge while avoiding corrosion due to dissimilar metals.
- Materials have the smallest physical dimension of water sprinkler systems which may be important in stacks
- Very long life expectancy of tube and fittings (greater than 100 years)
- Smoke scrubbing ability to reduce smoke damage
- Thermal blocking ability to limit heat damage.
- No environmental impact.
- High resistance to false discharge

Disadvantages

- Higher initial installation cost
- A location will need to be established for the pump and control equipment
- Electrical demand for pump motors

- A large amount of installation work throughout the building
- Relatively few manufacturers and installation contractors who can perform the work.

7. Total Flooding Water/Nitrogen Sprinklers. This option will use a water/nitrogen hybrid system similar to the Victaulic Vortex system. This has an open “deluge type” nozzle with a minimum one per room. In book stacks and other spaces where storage geometry impacts the mist pattern, additional nozzles will be needed. Water to the nozzle is controlled by thermal or smoke sensors that activate a respective zone control valve through a logic based fire alarm control panel. A second tube brings nitrogen to each nozzle and as nitrogen is blended with water the mist is formed. Mist will then fill the entire space until water and nitrogen flow is ceased.

#### Advantages

- The system uses extremely low quantities of water, which are among the lowest of any of the water-based system.
- Very low levels of dampening and saturation onto collections.
- Minimal water runoff to lower levels
- Minimal added weight to shelving systems
- The system does not require a fire pump to achieve pressurization.
- The room does not have to be air tight as necessary for gas agent systems
- Smoke scrubbing ability to limit smoke damage
- Thermal energy blockage to limit heat damage

#### Disadvantages

- The system does use water and therefore some wetting will occur.
- The system is a zone system, which discharges water and nitrogen throughout the protected compartment. It cannot be effectively isolated to only fill a part of the compartment
- Each zone requires one or more nozzles, water and nitrogen lines to each nozzle, a thermal or smoke detection zone for each compartment and a control valve unit for each compartment. This can result in a rather complex system. For example if this systems is used on the concourse level more than 40 zone control valves with appropriate detection and water/nitrogen lines each will be needed.
- The system has been extensively studied for industrial applications but there is little information about it effectiveness for large class A (paper, etc.) commodities.
- The quantity of nitrogen that must be stored will be comparable to the Inergen option. This is a very large number of cylinders that will require a large amount of floor space.
- System duration is longer than with a gas system but is limited by the quantity of stored nitrogen
- Nitrogen may concentrate on lower levels to produce a suffocation risk.

#### Summary

Fire suppression is a very important part of the library’s fire protection program. The proper selection and operation of suppression systems can significantly limit the amount of loss and impact recovery time and expenditure. The following matrix provides a relative summary for each viable option.

**Fire Suppression Matrix (0 = least 5 = best)**

Option	Response Speed	Effectiveness	Residual Damage	Resistance to False Discharge	Cost	Long Term Availability	Environmental Impact	Total
FE-25	4	3	4	2	4	0	0	17
FM-200	4	3	4	2	4	0	0	17
Inergen	4	5	4	2	4	3	5	27
Novec	4	3	4	2	4	3	3	23
Standard Sprinkler	2	4	2	5	3	5	5	26
Mist Sprinkler	3	5	3	5	4	5	5	30
Vortex	4	3	1	2	4	4	5	23

In conclusion:

The vaults should be fitted with high-sensitivity air sampling smoke detection (VESDA).

High-pressure water mist represents the most viable option for protecting the museum's vault spaces. This can be arranged with a centralized pumping unit that has its own dedicated clean water tank, or can draw filtered water from the public main. The system will be arranged in a pre-action manner with pre-discharge signal from the smoke detection system.

If specific collections items are highly water sensitive, a separate sub-vault should be constructed and either Inergen or Novec can protect this. Given the smaller quantity of agent that is needed, the advantage should go to Novec.





## **New Collections Storage Equipment**

Recommendations for appropriate new collections storage equipment are based on SBGA's 2004 study of collections needs and are illustrated in the storage layout plans. Briefly, Hiatt Second Floor Crate Storage and one half of North Storage will receive new overhead suspended painting screens, greatly increasing the capacity for storage of paintings and other framed objects and works on paper. Existing almost non-functional painting screens in North Storage are installed on two foot centers resulting in large volumes of wasted space. New screens will be installed on 12" and 18" centers, and spacing will be adjustable to accommodate changing collections needs.

Existing cabinets are slated to be installed on new mobile compact bases in Textile storage which will also house existing flat files. The heavy duty roll storage rack at the west end Textile Storage will remain, while the smaller metal roll storage racks will be replaced by new racks with greater ease of access and more flexibility for storing rolls of different lengths.

One half of North Storage and all of Objects Storage will be devoted to new long span and four post storage shelving mounted primarily on mobile bases. Units against walls will generally be stationary.

Existing storage units in PDP Storage will remain until a long term solution for storage of works-on-paper collections is determined.



**Improvement Scope, Cost, & Phasing**

**Scope** For purposes of cost and phasing, improvements to collections storage areas have been separated into discrete, standalone projects rather than a single renovation project. Although more expensive, this approach will be less disruptive to Museum operations and will allow more flexibility for phasing to match the Museum's developing Master Plan and planned Capital Campaign. Detailed information on the scope, costs, and recommended phasing in the documents following this introduction. The storage areas included in the recommended improvement program are the following

1932 Building

- North Storage
- Textile Storage
- Objects Storage
- East Storage (limited)

Hiatt Wing

- Second Floor Crate Storage
- PDP Storage (limited)

**Cost** The following chart contains conceptual budget costs for each area including

- Construction Costs for Room Improvements Including MEP Systems
- Collections Storage Equipment Costs
- Contingency & Soft Costs

Storage Area	Construction Cost	Storage Equipment Cost	Soft Costs & Contingency @ 50%	Total Project Cost
Hiatt 2nd Floor Crate Storage	\$215,590.00	\$89,900.00	\$152,745.00	\$458,235.00
Textile Storage	\$307,940.00	\$90,000.00	\$198,970.00	\$596,910.00
Objects Storage	\$314,390.00	\$112,500.00	\$213,445.00	\$640,335.00
North Storage	\$712,205.00	\$333,900.00	\$523,052.00	\$1,569,157.50
East Storage	\$257,440.00	NA	\$128,720.00	\$386,160.00

Not included in the costs are the costs that Museum is likely to incur in staff time for such activities as:

- Packing and moving collections
- Rental of temporary storage space or fit out of existing museum gallery space for temporary collections storage

- Preparation of new collections storage equipment and collections objects for move back to permanent storage (new housings and/or supports for objects, installation of padding on shelving, location tagging of new storage equipment, etc.)

Because of the very conceptual nature of the cost estimates a contingency of 15% has been included.

Soft Costs include generally:

- Design fees for architect, engineers, storage planner, and other consultants
- Investigative work (see Scope of Work for examples)
- Testing during construction activities
- Legal expenses
- Permits
- Owner's Project Management Expenses

Costs for improvements to East Storage may be higher than necessary. If investigative work concludes that treatment of exterior walls in the recent renovation is adequate, the costs could drop substantially, leaving HVAC, Fire Protection and Lighting improvements as the scope of work.

Although no costs for PDP Storage have been included above, it is recommended that the existing Halon fire suppression system be replaced with a misting system.

**Phasing** The following phasing sequence is recommended as a practical way to proceed with the scope of work with the least disruption to Museum activities.

1. Hiatt Second Floor Crate Storage
2. Relocation of Photo Studio and Registrar's Offices and renovation of space for collections storage.
3. Renovation of Textile Storage (This will allow extension of fresh air ductwork through the room to feed AHUs in central corridor serving Textile Storage, Object Storage, North Storage and possible future Storage in Registrar's Office/Photo Studio area).
4. Objects Storage (Extend ductwork through room to feed possible future storage in Registrar's Office/Photo Studio area).
5. North Storage
6. Possible relocation of PDP Storage to new storage area in Registrar's Office/Photo Studio area.



**Worcester Art Museum  
NEH Grant Proposal****Scope of Work  
Storage Room Renovations****General**

- In order to accomplish the scope of work for each storage room described below, each room will need to be completely emptied of all collections. Since this will entail finding temporary storage space within the Museum to house collections during renovations, it is likely that the work will be phased to renovate each room as an individual project.
- Storage rooms in the Hiatt Wing are served by the same HVAC system that serves galleries and other rooms within the Hiatt Wing. HVAC systems in each room will need to be shut down and isolated from the rest of the systems during renovations within the rooms to avoid distribution of dust and fumes to other areas. Because partitions between storage rooms and adjacent spaces will require modifications, adjacent rooms will be impacted and may have to be closed for periods of time during construction.
- In basement storage rooms North Storage, Objects Storage, and Textile Storage it will be necessary to provide exhaust to the exterior and a tempered ventilation air supply from the exterior during pouring and curing of new concrete topping to avoid influencing temperature and relative humidity in adjoining spaces. Rooms must be kept negative during this period.
- Construction access to individual basement rooms while adjacent rooms contain art work must be carefully controlled and planned. The best construction access to these rooms may be through the adjacent Registrar's Office Area.

**Hiatt Crate Storage H204 (To be converted to large painting storage)**Investigative Work

- Perform blower door test on room before construction to identify avenues of air leakage.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.

Architectural (See Simpson Gumpertz & Heger Report for Further Details)

- Remove steel posts used for Mosaic panel support.
- Remove all gypsum board from interior surface of studs at exterior walls.
- Remove suspended ceiling.
- Extend all GWB finishes on interior walls to floor construction above and seal. Tape all GWB joints.
- Extend GWB finishes on interior walls to the CMU exterior wall backup where interior walls meet exterior walls. Seal against exterior wall CMU. Tape all GWB joints.
- Apply a continuous fluid-applied, vapor-impermeable membrane serving as an air barrier and vapor retarder to the interior surface of the CMU backup wall, lapping onto the underside of the slab above, the top side of the floor slab and the GWB closures at sides of room. Provide a continuous air seal at interior side of steel spandrel beam and intersection with floor/roof structure above. Detail all penetrations through CMU airtight.

- Reinstall fiberglass faced GWB on interior of studs at exterior wall, taping all joints and sealing to slab above and below.
- Seal all penetrations of ducts, sprinkler piping, conduits, structural members, etc penetrating walls and slabs in room.
- Installation of new ceiling is optional. If new ceiling is installed GWB is preferred.
- Paint all GWB surfaces with acrylic latex low-VOC paint with a minimum permeability of 5 perms.
- Paint bottom of floor deck above and all ductwork, piping, conduit, structural members and other exposed non-integral finish items with low VOC white paint.
- Add gaskets to room doors to reduce air leakage.

#### HVAC

- Existing supply and return in room to remain.
- Balance air supply and return to maintain space at a positive pressure.
- Add temperature and relative humidity monitoring points to report to HVAC control system.

#### Electrical

- Install new suspended light fixtures with up component to light ceiling. LED fixtures preferred. Equip with UV filtering sleeves and/or lenses if fluorescent sources are used.
- Install duplex power outlets for inspection lights and computers if additional are required.
- Install wireless data point if wi-fi reception in room is not adequate.

#### Fire Protection

##### *Detection*

- Install a new VESDA fire detection system in room.

##### *Suppression*

- Install new water mist fire suppression system in room fed from new central pump station in basement.

#### Collections Storage Equipment

- Install mobile floor-supported painting screens and fixed wall braced painting screens to room.
- Evaluate layouts provided by Brian Ackley of Indoff, Inc and SBGA in the 2004 report for efficiency, capacity and access.

#### **Hiatt PDP Storage H106**

##### **Note 1**

**This work has not been priced in construction estimate as the report recommendation is to relocate PDP Storage and Paper Conservation elsewhere in the building. If PDP is to remain in its existing location the following work must be performed.**

##### **Note 2**

**If a new central water mist fire protection center is installed in basement, the existing Halon system in this room should be replaced by a water mist system even if other work in the room is not undertaken.**

#### Investigative Work

- Confirm floor load capacity and deflection criterion of first floor slab.
- Analyze capacity of floor to support loads imposed by new compact mobile storage equipment as shown in layouts by SBGA and Indoff/Aurora with deflection of no more than L/500.
- If floor must be strengthened, investigate feasibility and cost of strengthening.

- Work items below dependent on confirmation of feasibility of upgrade of floor load capacity to support mobile storage equipment.
- Perform blower door test on room before construction to identify avenues of air leakage.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.

#### Architectural/Structural

- Remove all built in wooden storage furniture. Salvage flat files in good condition for reuse.
- Remove all gypsum board from interior surface of studs at exterior walls.
- Remove suspended ceiling.
- Extend all GWB finishes on interior walls to floor construction above and seal. Tape all GWB joints.
- Extend GWB finishes on interior walls to the CMU exterior wall backup where interior walls meet exterior walls. Seal against exterior wall CMU. Tape all GWB joints.
- Apply a continuous fluid-applied, vapor-impermeable membrane serving as an air barrier and vapor retarder to the interior surface of the CMU backup wall, lapping onto the underside of the slab above, the top side of the floor slab and the GWB closures at sides of room. Provide a continuous air seal at interior side of steel spandrel beam and intersection with floor/roof structure above. Detail all penetrations through CMU airtight. Extend into recesses at window frames and integrate with window frame treatment. Provide continuous air seal at window-to-air barrier membrane at rough opening.
- Reinstall fiberglass faced GWB on interior of studs at exterior wall, taping all joints and sealing to slab above and below.
- Seal all penetrations of ducts, sprinkler piping, conduits, structural members, etc penetrating walls and slabs in room.
- Install new ceiling, GWB is preferred.
- Paint all GWB surfaces with acrylic latex low-VOC paint with a minimum permeability of 5 perms.
- Add gaskets to room doors to reduce air leakage.

#### HVAC

- Existing supply and return in room to remain. Install new supply and return diffusers as required by new ceiling
- Balance air supply and return to maintain space at a positive pressure.
- Add temperature and relative humidity monitoring points to report to HVAC control system.

#### Electrical

- Add new suspended light fixtures with up component to light ceiling. LED fixtures preferred. Equip with UV filtering sleeves and/or lenses if fluorescent sources are used.
- Add duplex power outlets for inspection lights and computers if additional are required.
- Add wireless data point if wi-fi reception in room is not adequate.

#### Fire Protection

##### *Detection*

- Install a new VESDA fire detection system in room.

##### *Suppression*

- Remove existing Halon fire protection system
- Install new water mist fire suppression system in room fed from new central pump station in basement.



### Collections Storage Equipment

- Install new four post shelving, solander box racks, framed work bins, flat files, and painting screens as required. See SBGA and Aurora layouts.
- Reinstall salvaged flat files.

### **North Storage MB05**

#### Investigative Work

- Analyze capacity of floor slab spanning tunnels to support loads imposed by new compact mobile storage equipment as shown in layouts by SBGA in 2004 report with deflection of no more than L/500.
- Analyze capacity of structural clay tile and granolith floor topping to support loads imposed by new compact mobile storage equipment as shown in layouts by SBGA in 2004 report.
- If floor must be strengthened, investigate feasibility and cost of strengthening.
- Identify all abandoned ductwork piping and conduit and tag for removal.
- Perform blower door test on room before construction to identify avenues of air leakage.
- Confirm existence of a waterproofing membrane on exterior of CMU window infill in window wells at north wall windows.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.

#### Architectural/Structural

- Remove all built in painting screens and guide mechanisms, shelving, and other storage furniture.
- Remove all abandoned ductwork, piping, and conduit.
- Remove all lighting fixtures
- Remove HVAC unit and associated equipment.
- If exterior waterproofing membrane at north wall windows does not exist, Remove drainage fill from window wells, install membrane and reinstall drainage fill.
- Remove steel casement window from openings in north wall.
- Install new CMU infill flush with interior wall surface in window openings. Provide flashings as necessary to deter water intrusion from exterior.
- Seal all avenues of air leakage identified in blower door test to prevent leakage of air from room.
- Install new closed cell spray applied polyurethane insulation (Insulstar by NCFI or equal), air/vapor barrier, studs and new interior fiberglass faced GWB on interior of north wall. See SGH report for details (drainage mat and trench drain at floor to be eliminated).
- Install new sheet vapor retarder on top of existing concrete slab.
- Install new un-bonded 3" thick concrete topping on floor after installing rails for mobile carriages for storage systems.
- Paint
- Air seal all penetrations of all new ducts, sprinkler piping, conduits, etc. penetrating walls and slabs in room.
- Paint all GWB surfaces with acrylic latex low-VOC paint with a minimum permeability of 5 perms.
- Paint all other room surfaces with appropriate low VOC paint.
- Replace doors to room with new 2hr fire rated hollow metal doors with gasketed perimeters and meeting astragal to reduce air leakage.

#### HVAC

- Install new air handler in Corridor MB13 supplied with hot and chilled water from central plant equipment. Install Dri-Steem or similar humidifier feeding supply air stream. Air handler to be capable of ducted supply and return air distribution. Air handler to be capable of handling a future supply of make-up air ducted from a dedicated fresh air supply unit located elsewhere. See system description in Exergen HVAC report.

- Install a ducted fresh air supply distribution system with diffusers supplying air downward along the exterior (north) wall.
- Install a ducted air return system with low returns along the south wall to draw air across the room.
- Install a new control system with temperature and RH sensors in critical points to control system. Controls shall report to BIM system.

#### Electrical

- Install power to new HVAC unit and humidifier.
- In 3D storage areas, install new suspended light fixtures with up component to light ceiling. LED fixtures preferred. Equip with UV filtering sleeves and/or lenses if fluorescent sources are used.
- In painting screen storage areas, install new downlight fixtures between overhead painting screen guide tracks as required to adequately light painting screens in pull-out position.
- Install duplex power outlets for inspection lights and computers as required.
- Install wireless data point if wi-fi reception in room is not adequate.

#### Fire Protection

##### *Detection*

- Install a new VESDA fire detection system in room.

##### *Suppression*

- Remove existing Halon fire protection system
- Install new water mist fire suppression system in room fed from new central pump station in basement.

#### Collections Storage Equipment

- Install new overhead suspended painting screens with floor supported overhead hanging structure and fixed painting screens per layout in SBGA 2004 report.
- Install new 3D storage equipment including long span shelving and platforms per layout in SBGA 2004 report.

### **Object Storage MB11**

#### Investigative Work

- Analyze capacity of structural clay tile and granolith floor topping to support loads imposed by new compact mobile storage equipment as shown in layouts by SBGA in 2004 report.
- If floor must be strengthened, investigate feasibility and cost of strengthening.
- Identify all abandoned ductwork piping and conduit and tag for removal.
- Perform blower door test on room to identify avenues of air leakage.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.

#### Architectural/Structural

- Remove all shelving, and other storage furniture. Salvage cabinets for reuse.
- Remove all abandoned ductwork, piping, and conduit.
- Remove all lighting fixtures
- Seal all avenues of air leakage identified in blower door test to prevent leakage of air from room.
- Install new sheet vapor retarder on top of existing concrete slab.
- Install new un-bonded 3" thick concrete topping on floor after installing rails for mobile carriages for storage systems.

- Air seal all penetrations of all new ducts, sprinkler piping, conduits, etc. penetrating walls and slabs in room.
- Paint all room surfaces including ductwork, piping, and conduits with appropriate low VOC paint.
- Replace doors to room with new 2hr fire rated hollow metal doors with gasketed perimeters and meeting astragal to reduce air leakage.

#### HVAC

- Install new air handler in Storage MB15 supplied with hot and chilled water from central plant equipment. Install Dri-Steem or similar humidifier feeding supply air stream. Air handler to be capable of ducted supply and return air distribution. Air handler to be capable of handling a future supply of make-up air ducted from a dedicated fresh air supply unit located elsewhere. See system description in Exergen HVAC report.
- Install a ducted fresh air supply distribution system with diffusers supplying air downward east end of room.
- Install a through wall air return grille with sound attenuator in west wall near HVAC unit.
- Install a new control system with temperature and RH sensors in critical points to control system. Controls shall report to BIM system.

#### Electrical

- Install power to new HVAC unit and humidifier.
- Install new suspended light fixtures with up component to light ceiling. LED fixtures preferred. Equip with UV filtering sleeves and/or lenses if fluorescent sources are used.
- Install duplex power outlets for inspection lights and computers as required.
- Install wireless data point if wi-fi reception in room is not adequate.

#### Fire Protection

##### *Detection*

- Install a new VESDA fire detection system in room.

##### *Suppression*

- Remove existing Halon fire protection system
- Install new water mist fire suppression system in room fed from new central pump station in basement.

#### Collections Storage Equipment

- Install new 3D storage equipment on fixed and mobile bases including long span shelving and platforms, and four post shelving, per layout in SBGA 2004

#### **Textile Storage MB15**

##### Investigative Work

- Analyze capacity of structural clay tile and granolith floor topping to support loads imposed by new compact mobile storage equipment as shown in layouts by SBGA in 2004 report.
- If floor must be strengthened, investigate feasibility and cost of strengthening.
- Identify all abandoned ductwork piping and conduit and tag for removal.
- Perform blower door test on room to identify avenues of air leakage.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.

Architectural/Structural

- Remove all shelving, textile racks, and other storage furniture. Salvage heavy duty rolled storage rack, rolled textile racks, flat files, and cabinets for reuse.
- Remove all abandoned ductwork, piping, and conduit.
- Remove all lighting fixtures
- Remove existing HVAC unit in corridor MB???? adjacent to room
- Seal all avenues of air leakage identified in blower door test to prevent leakage of air from room.
- Install new sheet vapor retarder on top of existing concrete slab.
- Install new un-bonded 3" thick concrete topping on floor after installing rails for mobile carriages for storage systems.
- Air seal all penetrations of all new ducts, sprinkler piping, conduits, etc. penetrating walls and slabs in room.
- Paint all room surfaces including ductwork, piping, and conduits with appropriate low VOC paint.
- Replace doors to room with new 2hr fire rated hollow metal doors with gasketed perimeters and meeting astragal to reduce air leakage.

HVAC

- Install new air handler in Corridor MB18 supplied with hot and chilled water from central plant equipment. Install Dri-Steem or similar humidifier feeding supply air stream. Air handler to be capable of ducted supply and return air distribution. Air handler to be capable of handling a future supply of make-up air ducted from a dedicated fresh air supply unit located elsewhere. See system description in Exergen HVAC report.
- Install a ducted fresh air supply distribution system with diffusers supplying air downward at north side of room.
- Install a through wall air return grille with sound attenuator in south wall near HVAC unit.
- Install a new control system with temperature and RH sensors in critical points to control system. Controls shall report to BIM system.

Electrical

- Install power to new HVAC unit and humidifier.
- Install new suspended light fixtures with up component to light ceiling. LED fixtures preferred. Equip with UV filtering sleeves and/or lenses if fluorescent sources are used.
- Install duplex power outlets for inspection lights and computers as required.
- Install wireless data point if wi-fi reception in room is not adequate.

Fire ProtectionDetection

- Install a new VESDA fire detection system in room.

Suppression

- Remove existing Halon fire protection system
- Install new water mist fire suppression system in room fed from new central pump station in basement.

Collections Storage Equipment

- Install new 3D storage equipment on fixed and mobile bases including long span shelving and platforms, four post shelving, and cabinets (new and salvaged) and flat files per layout in SBGA 2004.
- Install salvaged textile roll storage racks and heavy duty rolled storage rack.

## East Storage MB04

### General Comments

- This storage room has been recently created and elements of its construction are not known. Pipe tunnels run along east and north walls of room. Mobile storage equipment salvaged from the Higgins Armory Museum has been installed atop tunnels and granolith and clay tile floor. Structural analysis of floors in other rooms should identify any potential problems with this installation.
- Exterior wall construction at north end of room is identical to North Storage. Exterior wall construction on east side of room is similar to North Storage except that the wall is 4" thinner and is completely exposed on the exterior side.

### Investigative Work

- Analysis of capacity of structural clay tile and granolith floor topping to support loads imposed by existing compact mobile storage equipment in other rooms can be used to analyze issues (if any) with this room.
- If floor must be strengthened, investigate feasibility and cost of strengthening.
- Construction of window infill and interior construction at exterior wall must be investigated to see if additional work is required to prevent leakage and condensation on interior of exterior walls.
- Identify all abandoned ductwork piping and conduit and tag for removal.
- Perform blower door test on room to identify avenues of air leakage.
- Repeat blower door test after completion of sealing operations to confirm efficacy of work.
- 

### Architectural/Structural

- Protect all existing storage equipment installed in room.
- Remove all abandoned ductwork, piping, and conduit.
- Remove existing HVAC fancoil units and piping.
- Seal all avenues of air leakage identified in blower door test to prevent leakage of air from room.
- If exterior wall construction investigation identifies need for remedial construction at exterior walls, remove existing interior finishes at exterior wall and install systems as described for North Storage at exterior walls.
- Air seal all penetrations of all new ducts, sprinkler piping, conduits, etc. penetrating walls and slabs in room.
- Touch up paint on all room surfaces and paint new ductwork, piping, and conduits with appropriate low VOC paint.
- Install gaskets on existing doors to reduce air leakage.

### HVAC

- Install new air handler at ceiling of Corridor MB17 supplied with hot and chilled water from central plant equipment. Install Dri-Steem or similar humidifier feeding supply air stream. Air handler to be capable of ducted supply and return air distribution. Air handler to be capable of handling a future supply of make-up air ducted from a dedicated fresh air supply unit located elsewhere. See system description in Exergen HVAC report.
- Install a ducted fresh air supply distribution system with diffusers supplying air downward at north side and east sides of room.
- Install a through wall air return grille with sound attenuator above door to room near HVAC unit.
- Install a new control system with temperature and RH sensors in critical points to control system. Controls shall report to BIM system.

### Electrical

- Install power to new HVAC unit and humidifier.

- Install wireless data point if wi-fi reception in room is not adequate.

#### Fire Protection

##### *Detection*

- Install a new VESDA fire detection system in room.

##### *Suppression*

- Remove existing Halon fire protection system
- Install new water mist fire suppression system in room fed from new central pump station in basement.

#### Collections Storage Equipment

- Repair any damage to existing storage equipment left in place during construction before reloading.



# Cole Contracting, Inc.

GENERAL CONTRACTOR

152 WEBSTER STREET WORCESTER, MASSACHUSETTS 01603

PHONE (508) 795-1556 FAX (508) 754-2073

December 29, 2015

Worcester Art Museum  
55 Salisbury Street  
Worcester, MA 01609-3196

Attn: Fran Pedone

Re: Art Storage Areas

We herein present BUDGET estimates to furnish all labor, material, equipment and supervision required for all work required for the Art Storage Rooms as outlined by Solomon+Bauer+ Giambastiani in the specifications and sketches.

## **Hiatt 204                      \$215,590.00**

All architectural as outlined.

### Electric

- Three (3) Type A fluorescent light fixtures
- One (1) single pole switch
- Ceiling motion sensor
- Four (4) general use duplex receptacles
- Rework fire alarm

### Alternate:

1. Change lights to LED, please add \$250.00
2. New GWB ceiling, please add \$4,200.00

### HVAC

- Air balance of all existing registers, grilles, diffusers for positive pressure.
- Add temperature and humidity monitoring points.

## **North Storage                      \$712,205.00**

All architectural as outlined.

### Electric

- Eight (8) Type A fluorescent light fixtures
- Seven (7) Type B fluorescent light fixtures
- Two (2) Type C fluorescent light fixtures



- Three (3) single pole switches
- Ceiling motion sensor
- Ten (10) general use duplex receptacles
- Power wiring for one (1) air handler and two (2) hot water pumps
- One (1) 120V circuit for Vesda system
- Rework fire alarm

Alternate:

1. Change lights to LED, please add \$2,665.00

HVAC

- One (1) Airtherm chilled water/ hot water fan-coil
- Sheet metal duct distribution system for Storage Room
- Connect fresh air ductwork from new fresh air main in corridor
- Registers, grilles and diffusers
- Chilled water piping from new mains in corridor
- Hot water piping from new mains in corridor
- Duct and pipe insulation, as per our design
- Air and water balance as required
- Automatic temperature controls
- Complete check, test and start of system

Mechanical Infrastructure

- One (1) Buffalo Forge central outdoor air AHU, as scheduled
- One (1) Shell & Tube Heat Exchanger
- Hot water pumps and specialties
- Sheet metal duct distribution system for Storage Rooms terminated local to each fan-coil and capped for future connection
- Chilled water piping mains in corridor, terminated local to each fan-coil and capped for future connection
- Hot water piping mains in corridor, terminated local to each fan-coil and capped for future connection
- Duct and pipe insulation, as required
- Air and water balance as required
- Automatic temperature controls
- Complete check, test and start of system
- Abatement of all pipes and ductwork

**Object Storage      \$314,390.00**

All architectural as outlined

Electric

- Six (6) Type A fluorescent light fixtures
- Four (4) Type B fluorescent light fixtures
- One (1) single pole switch
- Ceiling motion sensor

- Four (4) general use duplex receptacles
- Power wiring for one (1) air handler
- One (1) 120V circuit for Vesda System
- Rework fire alarm

Alternate:

1. Change lights to LED, please add \$1,075.00

HVAC

- One (1) Airtherm chilled water/ hot water fan-coil
- Sheet metal duct distribution system for Storage Room
- Connect fresh air ductwork from new fresh air main in corridor
- Registers, grilles, and diffusers
- Chilled water piping from new mains in corridor
- Hot water piping from new mains in corridor
- Duct and pipe insulation, as per our design
- Air and water balance as required
- Automatic temperature controls
- Complete check, test and start of system
- One (1) year complete system warranty
- Abatement of pipes

**Textile Storage      \$307,940.00**

All architectural as outlined

Electric

- Six (6) Type A fluorescent light fixtures
- One (1) single pole switch
- Ceiling motion sensor
- Four (4) general use duplex receptacles
- Power wiring for one (1) air handler
- One (1) 120V circuit for Vesda System
- Rework fire alarm

Alternate:

1. Change lights to LED, please add \$375.00

HVAC

- One (1) Airtherm chilled water/ hot water fan-coil
- Sheet metal duct distribution system for Storage Room
- Connect fresh air ductwork from new fresh air main in corridor
- Registers, grilles and diffusers
- Chilled water piping from new mains in corridor
- Hot water piping from new mains in corridor
- Duct and pipe insulation, as per our design
- Air and water balance as required
- Automatic temperature controls

- Complete check, test and start of system
- One (1) year complete system warranty
- Abatement of pipes

### **East Storage \$257,440.00**

All architectural as outlined

#### **Electric**

- Three (3) Type A fluorescent light fixtures
- One (1) single pole switch
- Ceiling motion sensor
- Four (4) general use duplex receptacles
- Power wiring for one (1) air handler
- One (1) 120V circuit for Vesda system
- Rework fire alarm

#### **Alternate:**

1. Change lights to LED, please add \$250.00

#### **HVAC**

- One (1) Airtherm chilled water/ hot water fan-coil
- Sheet metal duct distribution system for Storage Room
- Connect fresh air ductwork from new fresh air main in corridor
- Registers, grilles and diffusers
- Chilled water piping from new mains in corridor
- Hot water piping from new mains in corridor
- Duct and pipe insulation, as per our design
- Air and water balance as required
- Automatic temperature controls
- Complete check, test and start of system
- One (1) year complete system warranty

#### **Exclusions:**

1. Raising the conduits in Textile and Object Storage.
2. Analyzing the capacity of the floor slabs.

#### **Notes:**

1. The removal of the ceiling in corridor MB 13 has been included in the North Storage Budget.
2. All rooms have the VESDA fire detection systems included. Also, all rooms have the misting suppression system included.

We hope these BUDGETS are helpful in your planning and if there are any questions please call at any time.

We thank you for the opportunity of estimating and hope we may be of service to you on this project.

Very truly yours,  
Cole Contracting, Inc.

**James A. Cole**

James A. Cole  
Sr. Vice President

JAC/jcc

### Storage Equipment Cost Estimate

The storage equipment cost estimate has been prepared using information from the bid prices from five different recent SBGA Collections Storage Design projects. The collections storage areas populated with storage equipment in the SBGA projects ranged in size from 45,000sf to 1,600sf. The total square footage of the WAM storage areas for which new storage equipment is being proposed is about 4,800sf. In Textile Storage, the cost per square foot amount has been adjusted to account for the reuse of existing cabinets presently housed in Objects Storage and Textile Storage. The cost per square foot of room area for painting screens has been adjusted upward to account for one-sided loading of the pull-out aisle. All costs have been calculated in the high range of SBGA experience as it is assumed that each room will be a separate renovation project and that the equipment for each room will be bid separately resulting in four small projects rather than one large one. To achieve the budget costs, it will be necessary to bid the storage equipment to at least two manufacturers, and to bid the 2D equipment as a separate package from the 3D equipment.

The budget equipment Costs are based on Layouts developed in 2004 for the storage rooms listed and are current costs without escalation for purchase in the future.

### Conceptual Budget Cost for New Collections Storage Equipment

Storage Space	3D Storage Equipment			2D Storage Equipment			Total Cost
	Area	Cost/SF	Total Cost	Area	Cost/SF	Total Cost	
North Storage	1270	\$125.00	\$158,750.00	1130	\$155.00	\$175,150.00	\$333,900.00
Object Storage	900	\$125.00	\$112,500.00				\$112,500.00
Textile Storage	900	\$100.00	\$90,000.00				\$90,000.00
Hiatt Crate Storage				580	\$155.00	\$89,900.00	\$89,900.00



## Phasing Alternatives

Because implementation of storage improvements is related to and part of a Museum Master Plan Initiative and future Capital Campaign, phasing will be informed by the priority of the goals of the Master Plan and overall distribution of activities within an existing or possibly expanded Museum complex. Expansion of Museum activities into nearby but unconnected buildings is also a Master Plan alternative that could affect both the location and sequencing of storage improvements.

The scope of this study has assumed that most collections storage will remain within the existing Museum footprint and that the basement of the 1932 Building (in spite of access difficulties) will remain the prime collections storage area for at least all but the largest collections objects. The assumption has also been made that for the short term, the Hiatt Second Floor Crate Storage area will be repurposed as large painting storage and that PDP storage will remain in its present location. It should be noted that the structure of the floor of the existing PDP Storage area is unlikely to have the structural capacity and/or proper deflection criterion to support densely compact mobile storage of sufficient capacity to allow for future growth of the collection. It has also been suggested that the space occupied by the storage area might be better used as gallery space due to its location within the building. The study has assumed that PDP will remain in its present location without improvement for the present and that storage space will be found elsewhere for expansion of PDP collections.

Deficiencies in the construction of the exterior walls of the Hiatt Wing have been an issue for the Museum for many years and without correction will make maintenance of a collections preservation environment in collections spaces (gallery, storage, or processing) within the building detrimental to the integrity of the exterior wall of the structure (See Simpson, Gumpertz & Heger report). The scope of work for renovations to the Hiatt second floor Crate Storage area include a difficult but very local improvement to the envelope of that space to mitigate the exterior wall deficiencies in that area.

The scope of work for storage areas within the Museum has assumed that the Museum will remain open and active during improvements to the storage areas and that to avoid moving all collections off-site, the improvements will be phased, affecting only one storage room at a time. This will necessitate finding swing space for storage of collections from each room or (in the case of North Storage perhaps half a room) while improvements to the rooms are undertaken. Many museums have temporarily closed one or two galleries to use as temporary storage while improvements are undertaken.

Another option for WAM is to find an alternative location for the Photo Area and Registrar's Offices in the basement of the 1932 Building and as the first phase of the storage improvement project, retrofit this space for collections storage. If this were done, the approximately 1350sf area could accommodate all the collections from Objects Storage or

Textile Storage, or one half of the collections from North Storage. This would have the added advantage of producing a storage area for future expansion of the collections or for compact storage of the entire PDP collection with room for expansion. The 1350sf area of the candidate space is the same size as the existing PDP storage room. This option has not been included in the scope of work, but is recommended. The sequenced renovation of North Storage (one half at a time) is not recommended due to complicated logistics which may present a danger to the collections.

A seemingly practical sequence of storage room improvements is as follows:

1. Hiatt Second Floor Crate Storage
2. Relocation of Photo Studio and Registrar's Offices and renovation of space for collections storage.
3. Renovation of Textile Storage (This will allow extension of fresh air ductwork through the room to feed AHUs in central corridor serving Textile Storage, Object Storage, North Storage and possible future Storage in Registrar's Office/Photo Studio area).
4. Objects Storage (Extend ductwork through room to feed possible future storage in Registrar's Office/Photo Studio area).
5. North Storage
6. Possible relocation of PDP Storage to new storage area in Registrar's Office/Photo Studio area.



